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BIDS FOR OCEAN CABLE are asked by the British Government. The bids are requested for the manufacture and laying in the Pacific Ocean of 8,272 nautical miles of telegraph cable between Vancouver and Fanning Island, Fanning Island and Fiji, Fiji and Norfolk Island, Norfolk Island and New Zealand, Norfolk Island and Queensland. It is proposed to divide the whole undertaking into three distinct contracts, for any one or more of which contractors may tender. Each of these contracts will include a clause under which the contractor guarantees the good electrical condition and working order of the cables for 30 consecutive days after the completion of the laying. A fourth contract is also proposed for surveying and sounding the whole route before the cables are laid. Forms of contract, specifications and tender may be obtained of Messrs. Clark, Forde & Taylor, 4 Great Winchester St., E. C., at whose offices charts showing the proposed route of the cables and the positions where soundings are to be taken may be inspected. The last day for the reception of tenders is Sept. 14.

THE "TELEPHONOGRAPH," a new invention in which the German Postmaster-General, Von Podbielski, is much interested, says Mr. B. H. Warner, Jr., U. S. Consul at Leipzig, is a combination of a telephone and a phonograph for the purpose of recording messages received during the absence of the operator. This apparatus was invented by a Dane by the name of Paulsen. The person called up has only to hold the trumpet to his ear upon returning to the office, even after an absence of days, to receive the message. Many inventors have tried to effect such a combination, but all failed on account of the difficulty of transferring the message onto a wax cylinder. Instead of a wax cylinder, Paulsen used a flexible steel band in his phonograph, which is much simpler in construction than the Edison phonograph. Messages are much more easily removed from the steel band than from the wax cylinder. It is wound on two spools, moving quickly from one to the other, and coming in contact with a very small electromagnet, switched into the circuit, which affects the steel band in such a way as to record on it any sounds that may penetrate to the phonograph. It is only necessary to cause the steel band to repass the magnet in order to have the sounds repeated. Each vibration of the electromagnet produces a corresponding vibration of the steel band. In order to remove a message from the steel band, a magnet is passed over the surface on which the message was recorded. The tests recently made in the engineering department of the Copenhagen Telephone Co., whose service the inventor has recently entered, were surprisingly successful. Up to the present time, the apparatus records a song better than a spoken message; but the latter is nevertheless quite clear, and the experts who have been making experiments in co-operation with the inventor declare that it is only a question of time until the telephonograph will repeat a message as clearly as it can be heard through the most improved telephone.

AN ELECTRIC CARTRIDGE has been invented by an Italian electrician which is offered as a substitute for dynamite and smokeless powder in mining, rock blasting and for heavy ordnance. According to U. S. Consul Hughes, of Coburg, the composition used in the cartridge is made up of carbonates of potash and chloride of ammonia, the proportion varying according to the use. The discharge is effected by an electric spark, which produces electrolytic effects upon the chemicals. The inventor claims that the cartridges, until subjected to the effect of electricity, are entirely inoffensive and perfectly safe; so that there will be no necessity for isolating the magazines where they are stored.

ANOTHER STREAM POLLUTION DECISION in Indiana has been handed down, this time, it is gratifying to note, against the defendant. The decision was rendered by the Supreme Court, in the case of Sarah Pope et al. vs. The Weston Paper Co., is as follows:

(1) A manufacturing concern located on the banks of a stream which it fouls and pollutes by discharging refuse therein so as to deprive lower riparian owners of the use thereof may be enjoined from continuing the pollution, and such riparian owners may recover damages for the injury.

(2) The fact that the concern has expended a large sum of money in the construction of its plant, and that it conducts its business in a careful manner and without malice, makes no difference in its rights to the stream.

(3) Before locating the plant, the owners were bound to know the rights of riparian proprietors, and to determine the location at their own peril, considering the capacity of the stream, etc.

(4) The fact that a water-course is already contaminated does not entitle others to add thereto, nor preclude persons through whose land the water flows from obtaining relief by injunction against its further pollution.

(5) Where the complainant, without notice or knowledge of the proposed corruption of the water, invited the erection of the plant at the place where it is located, he is not estopped from asserting a claim for damages and injunction.

Earlier Indiana decisions were noted in Engineering News for Oct. 26, 1893; June 4, 1896; and Nov. 9, 1899.

THE WATER SUPPLY OF CHICAGO was declared by the health board, on July 24, to be dangerous and boiling advised. Such notices were frequent before the drainage canal was opened, but this is said to be the first one since then. A heavy rain is said to have washed filth from the river into the lake.

WATER PURIFICATION AT ALLEGHENY, PA., is under consideration. A resolution designed to ascertain the cost of filtration has been referred to the water committee of the common council. The supply is now drawn from a large filter crib in the Allegheny River, as described in our issue of May 17, 1900.

WATER PURIFICATION EXPERIMENTS at New Orleans have been recommended by the executive committee of the sewerage and water board and the recommendations have been adopted by the board. This is in accord with the advice given recently by the advisory board. The proposal is to study the effect of sedimentation, followed by slow sand and by mechanical filtration.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Burlington, Kan., on the line of the Chicago, Rock Island & Pacific Ry., on July 23. Two passenger trains collided head-on as a result of misreading of orders. Three persons were killed and both engines were badly wrecked.

A FAST RUN WITH A MOTOR CARRIAGE has been made between Newport, R. I., and Boston, Mass., by Mr. W. K. Vanderbilt, Jr. The machine is of French make, and the distance of 75 miles was made in 2¾ hours on the first and 3 hours on the return trip.

STEPS PRELIMINARY TO MUNICIPAL OWNERSHIP of water-works at San Francisco have been taken. The supervisors have instructed the city engineer and board of public works to ascertain the value of the physical property of the Spring Valley Water-Works Co., exclusive of water rights and land.

TESTS OF BRAKE SHOES will be made by the Brake Shoe Test Committee of the Master Car Builders' Association during the month of March, 1901. Any railway company having in use or under consideration for use new brake shoes which have not previously been tested may have them tested at this time. The chairman of the Committee is Mr. S. P. Bush, Superintendent of Motive Power, Chicago, Milwaukee & St. Paul Ry., Milwaukee, Wis.

THE IMPROVEMENT OF THE RIVER DNIEPER in Russia is contemplated in a concession recently granted by the Russian government to an English syndicate. The lower third of this stream consists largely of rapids. Along one stretch the river falls over 65 ft. in ten miles. Below this place are a series of granite rocks, forming a barrier across the stream. In summer the water is scarcely more than 5 ft. deep above them and the entire descent in a distance of 46 miles is 157 ft. There are no actual falls in this stretch, and many stout, small boats run the rapids, but none of them can return up the river, and all the boats carrying cargoes down to the Black Sea are broken up either at Kherson or elsewhere and sold for building purposes. Several attempts have been made to canalize the obstructed part of the river, but none has yet succeeded. An English company has received a concession from the Russian government to undertake rendering the river navigable. The government has given to the company the right to use the water power for 80 years with a guarantee of 3% interest on the capital invested. The company proposes to build dams at various points and thus secure such depth of water as will cause the rapids to disappear. It is expected that the water impounded behind the dams will supply water power which will be utilized for industrial purposes.

A LARGE ROUNDHOUSE recently built by the Chicago & Northwestern Ry. at Clinton, Ia., has inside and outside diameters of 106 ft. and 187 ft. 6 ins., while the length of the longest locomotive and tender is 62 ft. 8½ ins., so that the stalls are of ample length. There are 30 tracks, two of which form the entrance and exit, leaving 48 for stalls. The turntable is 70 ft. diameter, and is operated by electricity. There is a pneumatic ash-hoist, and the building will be heated by the Sturtevant hot-air system.

A HIGHWAY BRIDGE OF 400 FT. SPAN has been built at Hamilton, O., and is said to be one of the largest spans of the ordinary pin-connected truss type for highway bridges ever built. The sidewalks are of concrete and the roadway is paved with asphalt blocks. The bridge was built by the Wabash Bridge & Iron Works, of Wabash, Ind.; the Osborn Co., of Cleveland, O., acted as inspecting engineers, and Mr. L. A. Dillon, of Hamilton, was the local engineer in charge.

AN INTERESTING AIR-SHIP TEST at Manzell, on Lake Constance, Switzerland, which was made on July 2, is described by U. S. Consul Dubois at St. Gaul, Switzerland. The ship, 407 ft. long and 39 ft. in diameter, and containing seventeen separate balloon compartments, filed with hydrogen gas, was floated out upon the waters of the lake on a raft. When all was made ready the balances were adjusted so as to give the ship an ascending direction, and the propellers were set in motion. With the wind blowing strongly at 26 ft. per second, the cigar-shaped vessel made a slow ascent, and started on her cruise through the air. For a total distance of 10 miles the ship soared high above the lake, reaching at one time an elevation of 1,300 ft. above its waters, when it suddenly stopped short, settled gradually, and floated safely on the water. The cause of the sudden stoppage in its flight was a slight mishap to the steering apparatus, but this happening created no danger, as the vessel sank upon the surface of the lake without taking any water. The trip consumed about 50 mins. The fastest time made was five miles in 17½ mins. The ship weighs 22,000 lbs., and cost considerably over $200,000.

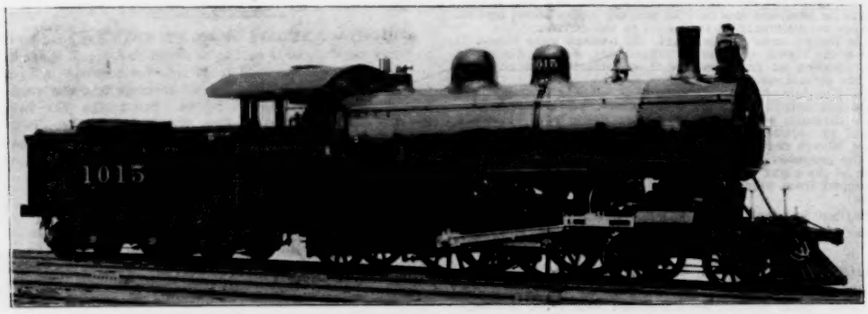
THE STATISTICS OF FOREIGN COMMERCE of the United States for the year ending June 30, 1900, which have been collected by the Treasury Bureau of Statistics, show the total imports of merchandise during the year to be $849,714,670, and the total exports to be $1,394,186,371. These statistics show that: (1) The total commerce of the year surpasses by $319,729,250 that of any preceding year, and for the first time in our history exceeds two billion dollars; (2) the exports exceed those of any preceding year, and have been more widely distributed throughout the world than ever before; (3) manufacturers' materials were more freely imported than ever before, and formed a larger share of the total imports than on any former occasion; (4) manufactured articles were more freely exported than ever before, and formed a larger share of the total exports than on any former occasion. In exports every great class of articles showed a larger total than in the preceding year; in imports every class except manufacturers' materials showed a smaller percentage of the total than in the preceding year, while manufacturers' materials showed a much larger total and larger percentage of the grand total than in any former year.

A DIAMOND CIRCULAR SAW for cutting stone is described in "Engineering" (London), and is said to cut hard sandstone blocks at the rate of 5 ft. per minute. The saw has dovetailed recesses in which are fitted steel blocks, each containing a diamond. A hole is drilled into the block, but stopped before running through. A diamond is dropped into the hole, and a steel wire-peg driven in behind it. The block is then put in an electric welding machine, and when it is softened, pressure is applied until the diamond is firmly gripped and the steel peg is welded into place. The front of the block is then filed away until the diamond is exposed, and the sides are milled to fit the dovetailed recesses in the saw. The positions of the diamonds in the blocks vary, so as to enable the saw to clear itself in making the cut. The machine was made by George Anderson & Co., of Carnoustie, Scotland.

A NON-RECOILING MAGAZINE RIFLE has been invented by Mr. Samuel N. McClean, of Cleveland, O., and is said to have a wonderful rapidity of fire. To manufacture and introduce the gun, the McClean Arms Co. has been incorporated in New Jersey, with a capital of $6,000,000; President, Marcellus Hartley; Treasurer, Charles R. Flint. The magazine holds five cartridges, but a continous belt of cartridges can also be used. The system is applicable to machine guns, and three sizes have already been made, including a rifle of 6 mm. bore and a 3.2-in. field gun.

NEW "NORTHWESTERN TYPE" PASSENGER LOCOMOTIVES; CHICAGO & NORTHWESTERN RY.

We illustrate in the accompanying cut one of the six heavy passenger locomotives of the "Northwestern Type," which are being built for service on the Chicago & Northwestern Ry., by the Schenectady Locomotive Works, of Schenectady, N. Y. This type of engine is considered by the builders to possess several advantages over the familiar "Atlantic Type," due to the peculiar arrangement and form of the frame, which permits the use of outside journals for the trailing truck axles. The more important of the advantages claimed may be summarized as follows: The points of support of the fire-box are wide apart. A wide fire-box with the ordinary form of frame necessitates considerable overhang, whereas with this form of frame the excessive overhang is obviated and the point of support at the mud ring is at its extreme width. This prevents excessive vibratory movements at high speeds. The construction also admits of the use of a more rational form of ash pan, and keeps the bearings well away from the heat of the ash pan. A large grate area and heating surface are possible, and this grate area is not obtained by having a fire-box of abnormal length, but is due to the possibility of increasing the width. It is also noted that the design provides opportunity for growth in this respect, and that the width of fire-box in this particular locomotive by no means establishes the limits of possible width. The engine has piston valves with inside admission.



NEW NORTHWESTERN TYPE HEAVY PASSENGER LOCOMOTIVE FOR THE CHICAGO & NORTHWESTERN RY.
Schenectady Locomotive Works, Schenectady, N. Y., Builders.

Regarding the general designing of the engine it may be noted that new drawings and patterns throughout were required. Complete calculations were made of the center of gravity, total weight and distribution of weights, and when the engine was completed it was found that the actual total weight and distribution of weights agreed almost exactly with the calculated ones, running slightly less throughout. The engine is provided with Westinghouse-American combined brakes for the drivers and trailers; a 9½-in. Westinghouse air pump; Westinghouse engineers' air signal; Vogt throttle valves; Tench sand-feeding apparatus; Golmar bell ringer, and three 3-in. Ashton open pop safety valves. The boiler and cylinders are lagged with magnesia sectional lagging. The trailing wheels under the back end of the engine are 48 ins. in diameter. The other principal dimensions and details are given below in our standard form:

Dimensions of "Northwestern Type" Passenger Locomotives.

Running Gear: Driving wheels	6 ft. 8 ins.
Truck and tender wheels	3 ft.
Driving wheel centers	Cast steel.
Truck wheels	"National" steel tired.
Driving wheel tires	Shrunk on.
Journals, driving axle.	9 x 12 ins.
Wheelbase: Driving	7 ft.
Total engine	26 ft. 9 ins.
Tender	16 " 10 "
Engine and tender	54 " 8⅜"
Weight in Working Order: On driving wheels	90,000 lbs.
Total engine	160,000 "
Tender empty	43,200 "
Coal in tender	16,000 "
Cylinders	20x26 ins.
Valves: Type	Piston.
Ports, steam 15⅝ ins.; Ports, exhaust	2¾ ins.
Bridges	1⅞ "
Maximum travel	6 "
Inside lap	Front and back, ¼-in.
Outside lap	1¼ "
Lead, full gear	Line and line.
Valve steam packing	Hemp.
Boiler: Type	Straight.
Barrel, diameter	5 ft. 8⅜ ins.
Barrel plates	11-16, ½, 7-16-in.
Horizontal seams.	Sextuple riveted.
Joints	Butt, inside and outside welt.
Circumferential seams.	Double riveted.
Firebox: Dimensions	8 ft. 6½ ins. x 5 ft. 5½ ins.
Depth Front, 6 ft. 4¼ ins; back 5 ft. 7 ins.	
Side, back and crown plates	⅜-in.
Tube plates	½-in.
Water spaces: Front	4 to 5 ins.
Back	3½ " 4½"
Sides	3½ " 5½"
Grate bars	Rocking.
Tubes: Material	Charcoal iron.
No. 338; Diameter	2 ins.
Length, over tube sheets.	16 ft.
Heating surface: Tubes	2,816.91 sq. ft.
Water tubes	28.27 "
Firebox	170.7 "
Total	3,015.88 "
Grate area	46.2 "
Miscellaneous: Exhaust nozzle	Single
Smokestack diameter....Top, 16½ ins.; bottom, 14 ins.	
Capacity of tender tank	5,200 gallons.
Coal space	8 tons.
Tender frame	10-in. steel channels.
Injectors	Two, Monitor No. 10.

HIGH-SPEED VERTICAL TRIPLE-EXPANSION ENGINE; CENTRAL ELECTRIC STATION, VIENNA, AUSTRIA.

(With two-page plate.)

In an endeavor to obtain greater steam economy, which, as is well known, depends on the size of engine, and influenced also by the local conditions, the Austrian General Electric Co. settled on triple-expansion units of 1,500 HP. as the size of the new engines to be installed in the Leopoldstadt central station at Vienna, Austria. This power-house now contains twelve vertical compound engines, each of 750 HP., direct-connected to Siemens & Halske direct-current generators. The new engines being of twice this size, will each drive two generators of the same type and make. A contract to build two machines after the design shown on our two-page plate was awarded to Friedrich Wannieck & Co., of Brünn, Austria, which firm had constructed seven of the original compound engines. We abstract the following description of the new engines from the "Zeitschrift des Vereines duetscher Ingenieure," of June 2, 1900, and reproduce from that journal the accompanying cuts.

The engines are designed to deliver 1,400 HP. to 1,700 HP., normally, with a maximum of 1,800 HP., using steam at 180 lbs. pressure and running at 135 revolutions per minute. The three cylinders, which stand side by side, have the following diameters: High-pressure cylinder, 22.8 ins.; intermediate cylinder, 33.5 ins., and low pressure cylinder, 55.1 ins., with a common stroke of 35.4 ins. The speed of the engine, which is normally 135 revolutions per minute, can be varied between 120 and 150 revolutions. This is made possible by the fact that the Proell governor is loaded with two heavy flyballs, aggregating 1,100 lbs. in weight, while the stem in the middle carries a total weight of 2,200 lbs. The weights may be shifted by the operator when on the first gallery by means of the hand-wheel H_1, and from the second gallery by means of the wheel H_2. The second gallery is at the rear of the engine, and the two engines are placed back to back for convenience in attendance. From this gallery the wheel H_6 operating the inlet valve; H_4, operating the exhaust valve A, and all the auxiliary valves are accessible.

There is further provided a device by which the adjusting lever of the governor can be shifted by the hand-wheel H, whereupon the admission to the high-pressure cylinder can be controlled by the operator by means of the hand-wheel H, the governor being then disconnected. Except when this device is used, which is very seldom, the governor works directly upon the Rider piston valve, shown in Fig. 1. The valve has inside admission. At the top and bottom it is packed with spring-rings, and it is provided with a cover allowing the expansion valve to be introduced. The three parts are held together by five heavy bolts, made very strong to withstand the steam pressure. The bolts are so arranged that the turning of the valve for different points of cut-off is not interfered with. It is worth remarking that this valve has withstood a pressure of 195 lbs. and a temperature of 250°C. without injury.

The intermediate cylinder is provided with a simple spring-ring packed piston valve, having inside admission, and has a fixed point of cut-off.

The low-pressure cylinder has four Corliss valves, Fig. 2, which are operated by rods from an eccentric. By changing the lengths of the rods the steam distribution can be adjusted. The three connecting rods are attached to three cranks placed at angles of 120°, the high-pressure cylinder leading. As the two engines are connected to a central jet-condensing plant, there are no air pumps attached. It should be added that the governor operates a balanced rotating throttle-valve, which at short admission throttles the steam pressure more and more, thereby assisting the governing and preventing the engine from racing with a sudden release of load.

In Fig. 3 are shown diagrams taken synchronously on the three cylinders, with 168 lbs. pressure in the steam pipe and 27.2 ins. vacuum in the exhaust pipe. The power of the egine at 122 revolutions per minute is 430 + 324 + 420 = 1,174 HP., the temperature of the steam being 214°C. The usual temperature of the steam entering the high-pressure cylinder is 240 to 250°C.; the lower temperature during the test was due to the fact that the boilers provided with superheating apparatus were at that time being cleaned. Usually the boilers with and those without superheaters discharge into a common steam main, resulting in an intermediate temperature of the steam.

To start the engine and to turn it over when making repairs, there is an auxiliary engine, which may be seen in the drawings on the two-page plate. It is a duplex reversing engine, and has rotary valves. The small flywheel is loose upon the crank-shaft, and may be used as a hand-wheel. The engine acts by a worm-reduction gear on the spindle of the worm S, which in turn meshes in the worm-wheel on the main crank-shaft. For the sake of safety it is so arranged that the worm S, which rests on a longitudinally movable shaft, is automatically shoved out and falls out of gear if the main engine starts up through an unintentional opening of the steam valves. In this way accident and breakage of the parts are avoided. For turning the engine backward, which is often necessary, the worm shaft is held from moving by a key, and to prevent accident in this case it is provided that in normal operation the key must be attached to the bracket L in such a way that the nose of the lever (a) is held in a vertical position. The lever (a) carries a signal, which in this position disappears within the hollow bracket L. If the key is removed from the bracket for the purpose of turning the engine backwards, the lever (a) falls down between the handles of the inlet-valve wheel H_6, which thereupon cannot be opened. The lever is shown in this position in the drawing on the two-page plate.

The engine is provided for continuous service with sight-feed oiling devices for the working parts. The oil is distributed from a central elevated reservoir. For the lubrication of the cylinders and valves there are provided five automatic pressure oiling devices. For the working parts about 0.66 lbs. of machine oil are used hourly, and for the cylinders and valves about 5.5 lbs. of cylinder oil.

RAILWAY DYNAMOMETER AND TEST CAR; ILLINOIS CENTRAL R. R.

A dynamometer car has for some time past been operated on the Cleveland, Cincinnati, Chicago & St. Louis Ry. by the engineering department of the University of Illinois, and has proved to be one of the most useful features of the railway equipment of that institution. This was described and illustrated in our issue of Nov. 24, 1898. A larger car with more complete equipment, designed for making tests of various kinds, is now being built by the Illinois Central R. R. The equipment will be furnished by the University of Illinois, and the car will be owned and operated jointly by the railway company and the university in experimental work as follows: (1) Measurement of train resistance; (2) Autographic track inspection; (3) Road tests of locomotives; (4) Air brake tests; (5) Station tests of pumping stations, etc.

The car resembles a large caboose, 40 ft. long over the end sills, and 45 ft. 4 ins. over the platform sill, with a width of 9 ft. over the side sills, and a total width of 10 ft. 5⅝ ins. over two projecting side windows near the front end, which give a view along the train. Above the roof, near the rear of the car, is a cab or look-out, from which the recording apparatus is controlled, as noted below. The car is mounted on a pair of four-wheel trucks, with a wheelbase of 6 ft. 6 ins., the distance c. to c. of trucks being 29 ft. 4 ins. Continuous draft timbers are fitted below the center sills. The total height above the rails is 14 ft. 11 15-16 ins. to the top of the look-out, which extends 3 ft. above the main roof and is the full width of the car. The framing is heavy and substantial, as the car will be used in very heavy freight service. The instruments for train resistance, track, air-brake and pumping station tests are mounted on four tables, at the sides of the working part of the car, which is about 25 ft. long. The look-out affords facilities for observing the handling of the train; in it are placed electric buttons controlling the signals to the operators below, and also the pens which mark on the dynamometer record the location of mile posts, stations, curves and grades. At the rear of the car, about 15 ft. of its length are occupied by lockers, berths, toilet room and a stove.

The equipment will for the present consist only of that for making dynamometer tests, and this is shown in the accompanying cuts. The pull or tractive power exerted on the drawbar is resisted by the piston in a cylinder filled with oil, and this pressure is transmitted by the oil to the recording and indicating gages in the car above. The record of the pressure is made on a continuous strip of paper 6 ins. wide, which is drawn past the marking pen at the rate of 13.2 ins. per mile by means of mechanism operated from the car axle. Besides the pressure line, the location of mile posts and stations, and the time, are marked upon the paper. The pen recording the time draws a continuous line, but is periodically drawn away from the paper by means of electro-magnets controlled by a clock making electric contacts every 5 or 10 seconds as desired. Another pen for marking the mile posts and stations also draws a continuous line, broken at intervals by withdrawing the pen from the paper by means of electro-magnets operated by push-buttons by an observer in the look-out. A separate chart of the speed is drawn by a Boyer speed recorder.

The oil pump receives its supply from the oil supply tank, and forces it through a system of piping into the three cylinders of the dynamometer. Compressed air, taken from the auxiliary reservoir of the air brake system, is used to clear the oil from the cylinders when necessary and also to aid in filling them and to blow back from the leakage tank whatever oil leaks by the pistons and stuffing boxes of the three cylinders. From the switchboard, electric connections are made to the various signals and pens, to the revolution counter in the car which shows the revolution of the driving wheels, and also to the electric signals for indicator cards at the front end of the engine. The dynamometer cylinders, shown in Fig. 1, are made in three castings held together by stud bolts not shown in the drawing. The effective area of the largest cylinder is 60 sq. ins., of the second 30 sq. ins., and of the smallest 5 sq. ins. It is intended that the working pressure of the oil in the cylinders shall be from 300 lbs. to 1,000 lbs. per sq. in. For this range of pressures the largest cylinder has sufficient capacity for the heaviest freight service, the second will be used when working with a train of ordinary tonnage, while the smallest will be used for passenger service. In this last case, the working pressure may be somewhat higher. If it should become necessary, the first and second cylinders can be coupled up in tandem, thus giving an effective piston area of 90 sq. ins.

The piston rod is connected to a drawbar yoke of special design, and is so arranged that when the piston travels forward too far beyond its working position the pull is taken on the springs of the ordinary draw-gear. Buffing strains on the rod are likewise received immediately by these springs. An electric tell-tale notifies the operator when the piston passes its proper limits of travel on account of the leakage of oil. The cylinders are reamed, the pistons ground and the piston rod ground where it passes through the stuffing-boxes. The stuffing-boxes were designed particularly for this arrangement and consist essentially of the inner sleeve or gland, which is ground internally to fit the rod and grooved as shown to help retard the leakage. The forward end of the gland is ground to a spherical form, and fits into a ground spherical seat in the stuffing-box casting. This spherical seat is used to permit the three sleeves to aline themselves properly on the rod. The pressure of the oil keeps the gland on its seat and the oil pressure is supplemented by the pressure of several helical springs placed between the rear end of the sleeve and the plate shown at the inner end of the stuffing-box.

Considerable difficulty was experienced in making the joints between cylinder and pistons and between stuffing-box and rod sufficiently good to prevent undue leakage; but this has now been overcome and the leakage under the upper limit of the working pressure, or 1,000 or 1,200 lbs. per sq. in., is not sufficient to interfere with the proper working of the apparatus. The pistons will move forward on account of the leakage; but so slowly that the cylinders can be refilled from the pump at stops, or if necessary when the cylinders are under pressure. This design was resorted to in order to avoid the uncertainty concerning the frictional resistance incident upon the use of the usual packed pistons and stuffing-boxes. The cylinders have been calibrated, in connection with their gages, upon an Olsen testing machine, and the total pull on the rod necessary to overcome

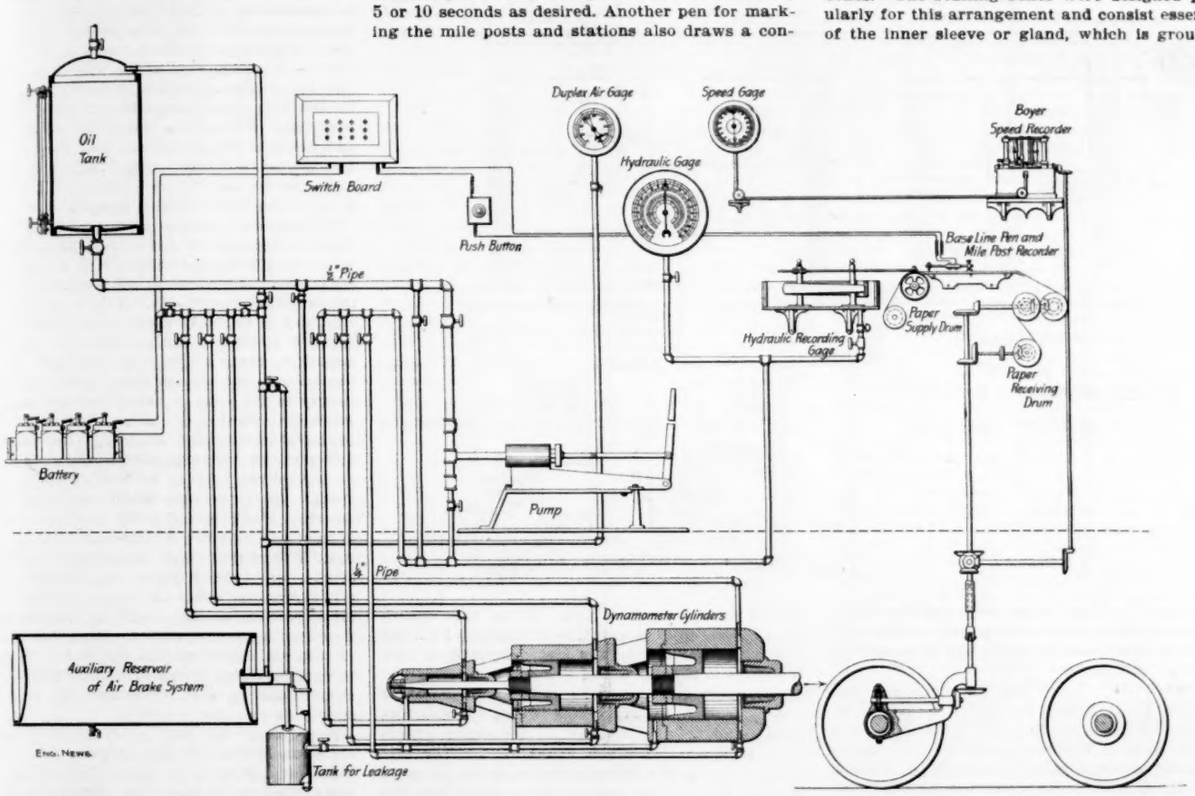


FIG. 1.—DYNAMOMETER AND RECORDING APPARATUS OF RAILWAY TEST CAR; ILLINOIS CENTRAL R. R. AND UNIVERSITY OF ILLINOIS.

the friction in the apparatus found to be about 30 lbs. The cylinders are secured to the draft timbers by means of the flanges shown at the sides and top.

Fig. 2 shows the table upon which are placed the dynamometer recording gage, the rolls for driving the paper chart, and the Boyer speed gage. The vertical shaft shown projecting through the floor under the middle of the table derives its motion from the car axle by means of spiral gears and bevel gears. Its motion is transmitted, by means of the gearing to the speed gage and the paper-driving mechanism. The latter consists of a pair of driving rollers (around which the paper passes), and a supply roller and receiving roller. The paper is drawn from the frame, passes over the drum of the recording gage, and is wound upon the receiving roller.

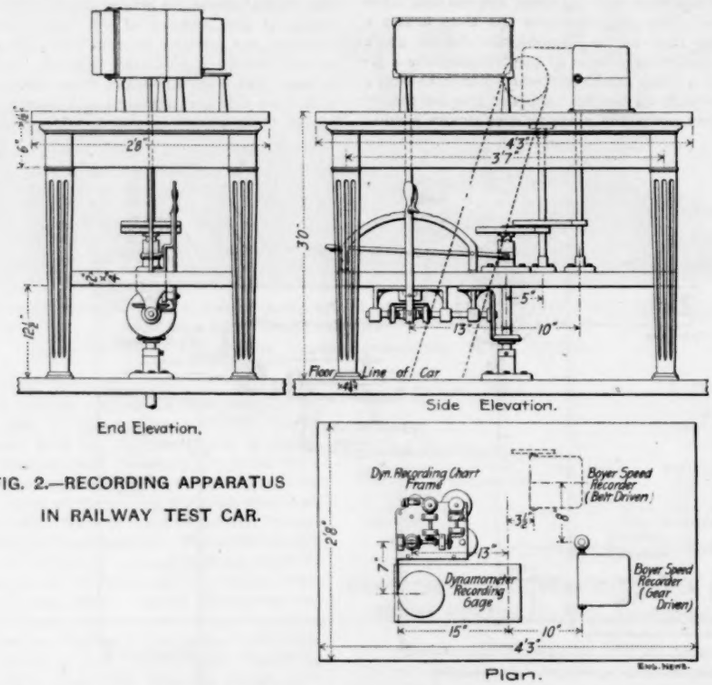


FIG. 2.—RECORDING APPARATUS IN RAILWAY TEST CAR.

The design of the car and its equipment has been worked out jointly by Mr. Wm. Renshaw, Superintendent of Machinery of the Illinois Central R. R.; Prof. L. P. Breckenridge, of the Department of Engineering of the University of Illinois, and Mr. E. C. Schmidt, Instructor in Railway Mechanical Engineering at the University.

REPORT ON ELECTROLYSIS AT PROVIDENCE, R. I.

The subject of electrolysis has been investigated at Providence, R. I., by Mr. A. A. Knudson, M. Am. Inst. E. E., of New York city, in conjunction with the water department. Mr. Knudson made some 150 potential tests, mostly to determine whether the water mains were acting as conductors for the Union Railroad Co. He found plenty of evidence that current was passing through the mains, the voltage in one instance being as high as 25. Some of the new high service fire mains are located in a district where both high and low service mains are constantly positive, the readings here generally ranging from one to two volts. While this is not high, Mr. Knudson says it is not a desirable condition, and that probably electrolysis is taking place, although an excavation at one point failed to show it on the outside of the pipe.

Along the Smith St. line the readings ranged from 4 to 6 volts, on a 24-in. water main, extending about 3½ ft. below the tracks, for two miles. An excavation in sandy soil, scarcely damp, showed electrolytic pittings on the positive side of the joint. In searching for the high difference in potential along this line a rail joint was uncovered. It showed a small two-bolt fish plate, a space between rail ends and a copper bond. Mr. Knudson believes the play at such joints as these breaks the wire where it is bonded in, thus accounting for the high difference in potential. Later on, still higher differences were found near a turnout, and excavations showed the copper bond broken at one end and corroded at the other.

In contrast with the poor track joints above this important water main, excavation showed a cast-weld joint on another line to be very complete and rigid.

Mr. Knudson states that in 1 ft. of ordinary-sized rail it is seldom that a difference of potential greater than 0.001 volt can be obtained, and that at good rail joints the difference should not exceed 0.1 volt; but in many of the rails tested, where joints were included, in a length of 1 ft., the difference was more than one volt, and in two instances it rose to 6 and 9 volts, respectively.

Excavations to the water mains were made at eleven points. In some cases, where the soil was damp, and the current flow in the mains excessive, electrolytic pittings were found. The pittings were not immediately serious, so far as could be seen, being, in all but one case, on the bell end of the pipe length, where the metal is heaviest. But the conditions may be worse at other places.

A line of old pipe, taken up some time ago, showed the effect of marked electrolytic action, both at the inner and outer ring of the bell.

Immediate danger to the water mains can be controlled if the water department will take frequent volt meter readings, and the street railway company will take prompt action to reduce the danger, where shown; but, Mr. Knudson says, there will be no assurance of safety so long as the single trolley is used, in which the rails form one side of the circuit and are in contact with the earth. He suggests that in the future all requests for extensions to street railway lines be referred to the city engineer for investigation as to their probable effect on water mains.

MUNICIPAL ENGINEERING EXHIBITS AT THE PARIS EXPOSITION.

(Editorial Corespondence.)

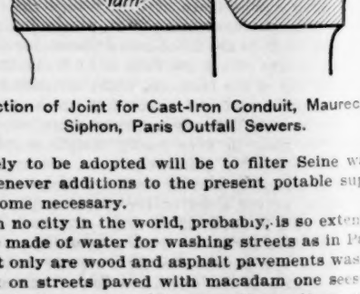
By far the most important and interesting of the exhibits in the class above named is the display made by the city of Paris itself. By this I do not allude to the well-kept streets and parks of the city, with which the visiting stranger is certain to be impressed, but to the special exhibit in the Ville de Paris building. Here is displayed in the greatest detail every work in which the municipal government of Paris is interested—sewerage, water supply, street construction, street cleaning, public lighting, schools, police, sanitary protection, hospitals, markets, etc., etc. A complete and detailed description of all that is displayed here would be a far bigger work on municipal engineering and municipal government than has ever been written. All that can be done in these columns is to note a very few features of especial interest.

As many readers will remember, Paris is the only great city of the world which has two systems of water supply, one of potable water, the other of impure water for street washing, sewer flushing, ornamental fountains, and similar uses. The potable water is brought from a number of large springs, some of them 90 miles distant, through gravity conduits. The other supply is chiefly pumped from the Seine, which flows through the heart of the city, and as the sewage is not allowed to enter, it is by no means so foul, in appearance at least, as the rivers from which some American cities draw their entire supplies.

The difference between the quality of the two waters is well shown in the Ville de Paris building by a large fountain in the central pavilion having four deep compartments lined with white porcelain. The spring water supply flows in to two of these compartments, and the Seine supply into the two alternate ones. The former is a limpid blue, while the compartments filled with the Seine water are gray and opaque.

The duplicate system of water supply has often been advocated for cities; but the objection always raised is that people will be careless and make more or less use of the foul water for drinking or culinary purposes. It does not seem to work this way in Paris, however; or at least the annual typhoid statistics, exhibited in the sanitary department, show a creditably low rate. A serious objection in the case of most cities to a duplicate supply is the cost of installing and maintaining duplicate systems of mains. This objection was partially obviated in Paris by the fact that the water mains are suspended in the sewers and the streets do not have to be torn up to lay or repair them. It is on the whole doubtful, however, whether Paris would have adopted a duplicate system had not the circumstances been so peculiar. The supply from the springs was large and of excellent quality, yet it was insufficient for the city's requirements. No other source whence a large potable supply could be secured could be found in a great distance. It appeared the part of wisdom, therefore, to apply the Seine water to uses for which it was equally as good as a purer supply, and thus so economize the spring water supply as to make it suffice.

Apparently, the only weak point in the water situation in Paris is the question how the spring water supply is to be supplemented, as it inevitably must be, to meet the continually increasing consumption. One scheme proposed by a French engineer and shown at the Exposition is to bring the waters of Lake Geneva to Paris, a distance of nearly 500 miles. Engineering, financial and political difficulties are pretty sure to prevent the success of so huge a scheme, and the course most likely to be adopted will be to filter Seine water whenever additions to the present potable supply become necessary.



Section of Joint for Cast-Iron Conduit, Maurecourt Siphon, Paris Outfall Sewers.

In no city in the world, probably, is so extensive use made of water for washing streets as in Paris. Not only are wood and asphalt pavements washed, but on streets paved with macadam one sees the street cleaners washing out the gutters every morning. The natural result of this method of street cleaning is the carriage of large quantities

of sand and silt into the sewers. The machinery for cleaning out this deposit forms an interesting part of the Ville de Paris exhibit. Small lateral sewers or larger submerged ones such as the siphons under the Seine are cleaned by drawing through them a wooden ball float slightly smaller than the sewer section. In the large sewers of which Paris has so great an extent either a car or a floating scow is run along the sewer, pushing a movable dam in front, and as the silt collects in front of this dam it is excavated by a clam-shell scoop worked from a boom on the scow. The machinery of this dredge is operated by electricity. In another model, the dredging bucket is suspended from an overhead rail, and the car into which it delivers runs on benches in the sewer bottom.

Where it becomes necessary to raise the sewage a short distance to secure sufficient velocity of flow, a paddle-wheel pump is sometimes used. It is similar to an old-fashioned breast water-wheel, only it raises the water from the lower to the higher level instead of being driven by it.

In the field of house sanitation an exhibit has been prepared showing sections of typical Parisian houses of 1830, of 1868 and of 1900. The sections are of very large size, so that the sewer, the water pipe and all the plumbing connections inside the house are clearly shown. In 1830, Paris, like most of the Continental cities, was in the dark ages so far as sanitary knowledge was concerned, and under the conditions shown, the wonder is that plagues and fevers did not decimate the inhabitants every year. Even in 1868, methods were very crude. The section labeled 1900 represents rather a model Paris house than an average or typical one of the present day. A good illustration of the fact that France is still behind England or America in matters of sanitary practice is seen in the building devoted to hygiene. Plumbers' goods are the chief articles shown here, and of the water closets exhibited under various high-sounding names, nine out of ten are the old-style pan closets.

Turning again to the sewerage of Paris, as already explained, the sewage of the city is not suffered to enter the Seine, but is carried by large conduits a dozen miles or so down the Seine valley to the sewage farms of Acheres. These farms are shown in the Ville de Paris building by a dioramic picture, in which real cabbage and lettuce are growing in the foreground, a wax woman is weeding them, and behind is the picture so well executed that it is hard to tell where the real cabbage leaves end and the painted ones begin.

In building the large outfall sewers for Paris, where the conduit was required to withstand internal pressure, extensive use has been made of steel and concrete pipe, consisting of a framework of steel wire wound in a spiral and held in place by longitudinals, and the whole embedded in a shell of concrete. An attempt was made to introduce pipe of this sort in the United States some years ago, but it met with small success—another illustration of the fact that the foreigner is often more hospitable to new ideas and new inventions than the American, the prevalent idea to the contrary notwithstanding.

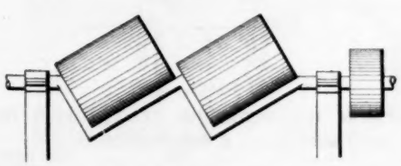
For sections of the siphon which had to withstand very heavy internal pressure, recourse was had to steel and cast iron. The Maurecourt siphon in the valley of the Oise is a cast-iron pipe of 78 ins. internal diameter, and as it was required to withstand a head of 85 ft., it is wound with steel wire at short intervals throughout its length. The lengths, which are 13 ft., end to end, are joined by hub-and-spigot joints, and the outside of the bell is wound with steel wire to strengthen it to resist not only the bursting pressure of the water, but the pressure due to calking the lead and any strains due to the settlement of the pipe after laying. The wire is covered with and embedded in asphalt to protect it from corrosion, all as shown in the accompanying sketch.

In the section where paving materials used in Paris are exhibited, there is a model of a peculiar tumbling barrel used for testing paving blocks. Its general outline is shown herewith. It has two compartments, as shown, and the axis of revolution passes through these diagonally, so that the material always falls on an inclined surface and is thrown first to one and then to the other as the barrel revolves. This should be a good machine for testing paving brick.

Queerly enough, nowhere in the Exposition, not even in the Ville de Paris building, is much to be seen of street cleaning machinery. One or two ordinary revolving broom machines, possessing nothing of novelty, are about the only exhibits in this line. There are some machines, however, in a similar line which might perhaps be studied to advantage by American engineers. I refer to automatic street sanders. In Paris and London, with their heavy cab and omnibus traffic and their great mileage of wood pavements, it is often necessary to put grit on the streets in wet or freezing weather to enable the horses to get a foothold. I have an impression that another reason for this is that horses are not shod with such long and sharp calks as in the States. At least, if this is not the case, I am unable to account for the remarkable wearing qualities of wood and macadam pavements. London wood pavements are not torn and broomed by the countless horses' hoofs which pass over them, like American wood pavements, but wear with a smooth, black, shiny surface. Similarly macadam is not roughened and torn up by the impact of horses' hoofs as one sees it in American streets. If it were it would be impossible to use macadam on the streets of heavy traffic where it is used in England and France.

Taking all these things together, the necessity of putting sand or gravel on smooth street pavements in certain weathers is evident. The machines referred to are simple arrangements for spreading the gravel evenly and very thinly over the pavement, and should be much more economical of both labor and material than spreading by hand.

In this connection a novel idea for making a non-slippery asphalt pavement is shown in the



Sketch of Double Tumbling Barrel for Testing Paving Materials, Used by the City of Paris.

French civil engineering section by the Company du Granite-Asphalt, 19 Rue de Rocroy, Paris. The binder layer of the pavement is laid in the ordinary manner, and while it is still soft, sharp pieces of granite or other hard stone, broken to a roughly pyramidal shape, are imbedded in the asphalt with their points upward, and just below the level of the surface of the finished pavement. The final layer of asphalt is put on over these granite points, fills the interstices between them and appears as smooth as an ordinary pavement. As the pavement wears, however, these hard granite points come to the surface and prevent the pavements from becoming slippery. Besides this, these pieces of granite firmly unite the surface layer to the binder and prevent creeping of the surface and wrinkling in hot weather.

In the English civil engineering section, the Septic Tank Syndicate, of London, show a working model of their system of sewage purification, with the automatic apparatus by which the flow from the septic tank is discharged upon one after another of the coke-bed filters alternately. A map is also shown on which are indicated the various towns in which this process is working in England, and it would appear that the process is meeting with widspread and increasing favor there. The system has been so fully described in Engineering News that it need not be referred to further.

In the field of water purification, some elaborate models are shown in the German civil engineering section of the Berlin water-works and filtering plants, and there are similar exhibits on a more modest scale from other cities. A greater novelty than these, though it is very likely of less practical importance, is an ozone water-sterilizing plant exhibited by Messrs. Marmier & Abrahams, of Paris. The ozone is manufactured by an alternating electric current of 40,000 volts, which produces a shower of sparks between parallel glass plates. The claim is made that water can be sterilized by this process in large quantities at a cost as low as 1 ct. per 1,000 gallons. Except for a small plant at Lille, it has not yet been applied to any public water supply.

In small filters, for household or industrial use, there is a great variety, and they appear to be generally better and more scientifically designed than the common American filters of this class. The influence of Pasteur and the reputation which the filter designed by him obtained may be in part responsible for this.

REPAIRING A BRIDGE PIER BY MEANS OF AN ANNULAR PNEUMATIC CAISSON.*

Two of the bridges across the river at Little Rock, Ark., are owned by the St. Louis, Iron Mountain & Southern Ry. Co. One of these consists of four fixed through Pratt truss spans, and one swing span, making altogether about 1,200 ft. of bridge. The piers are of stone masonry resting on timber caissons sunk to the rock about 45 ft. below low water line. These piers and bridges were built in about the year 1884-85. Shortly after being built, the pivot pier, holding up the swing span, and one other pier, began to lean up stream. This threw the bridge out of line, and it had to be moved back and wedges put under to level it up in order to operate the swing span readily. The leaning continued, however, till in the summer of 1898 the top of the masonry overhung the bottom by over a foot, and the turntable drum had been moved over as near one edge of the pier as it was safe to put it. It was then decided to stop the leaning if possible, and the contract was let to the Missouri Valley Bridge & Iron Works, of Leavenworth, Kan., Mr. A. J. Tullock, Chief Engineer, and Mr. L. S. Stewart, Superintendent in Charge. Work was commenced in September, 1898. A pneumatic timber caisson was to be sunk surrounding the pier. This task was very difficult owing to the large size of the caisson, the swift current and rapid rising of the water in the river, and to the materials encountered in the bottom of the river.

As the caisson was to be sunk around a pier already built, it could not be put together on shore and floated into position, but had to be built above water around the pier on a pile support and then lowered into the water. As there were not more than 5 or 6 ft. of sand overlying the rock beneath the river bottom, the piles had to have an extra amount of bracing to keep them upright. The load was to be quite considerable and at a distance of about 4 ft. above low water mark, making about 45 ft. that the piles extended above the yielding sand in the river bottom. This bracing was accomplished by making a loop of chain about 18 ins. in diameter spiking it to the end of a 2 × 12 × 18-in. plank, then letting the loop down around one of the piles with the plank held nearly vertical till it was about 15 ft. below the water surface. The loop being now around both pile and plank, the top of the plank was brought over, tightening the chain as it came, till the end of the plank came down alongside another pile, where it was securely spiked.

The masonry pier is 30 ft. in diameter, resting on a square timber crib 32 ft. on a side. The crib, which is an extension of the caisson underneath, reaches up to within 1 ft. of low water mark. The new caisson to be sunk around this was also square, the inner wall nearest the pier being 46 ft. on a side and the outer wall being 70 ft. on a side, leaving 7 ft. between the old caisson and the new, and 12 ft. between the outer and inner walls of the new caisson. At 6 ft. above the bottom or cutting edge of the new caisson was a roof built in from wall to wall, the space underneath being the air or working chamber, and the space above for sand filling to give the weight necessary for sinking. Southern pine sticks 12 × 12 ins., dressed on four sides, were used in building. The timbers in each course were dapped together, and the courses were drift bolted together. Drift bolts were ⅞-in. in diameter by 2 ft. 10 ins. long, and were driven into holes bored 1-16-in. less than their own diameter. In this way each course was securely fastened to two courses below. Drifts were spaced about 3 ft. apart. Seven courses of the caisson were put together on the pile support before it was lowered into the water. This included the cutting edge and the sides and roof of the working chamber. The sides of the chamber were 3½ ft. thick, and the roof 2½ ft. thick. All spaces between timbers in the chamber and on the outside of the walls were carefully calked with oakum.

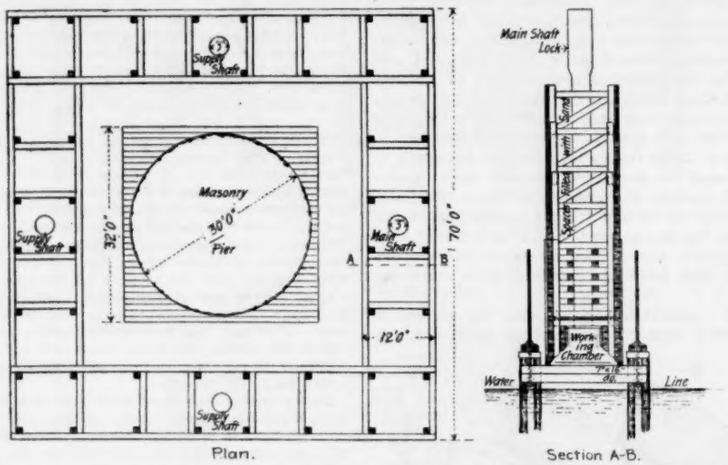
The lowering of the caisson into water was accomplished as follows: Imagine the caisson resting on the floor beams of a bridge and instead of the usual hangers at the ends, screws 3 ins. in diameter are used. These screws run up through a 12 × 12-in. cap on the piles, and nuts are

*Condensed from an article by Mr. Edward M. St. John in the 1900 "Technic" of the University of Michigan Engineering Society.

screwed on from the upper end down against this cap, or rather against a washer on the cap. By turning these nuts the floor beams could be raised or lowered, and with it the caisson. Wrenches with handles 5 ft. long were used to turn these nuts, and three men operated each wrench. Twenty-four of these lowering screws 3 ins. in diameter by 22½ ft. long were used, and about 80 men were needed to operate them. All the nuts were moved simultaneously, the "course around" shouted by the foreman being the signal for every man to move his wrench a quarter turn. The lowering was done at the rate of about 1 ft. per hour.

A calculation of the weight of a cubic foot of timber was made from the displacement in the water; it was 45 lbs. This was for unseasoned pine cut about one month.

It was a great relief to get the caisson floated. The building now went rapidly forward, the caisson sinking gradually as the courses were placed on top until finally the bottom of the river was reached. The bottom, however, was very uneven at this place. The current was swift and the presence of the bridge pier had caused the bottom to be scoured out in some places and the sand heaped up in others. So, while one part of the cutting edge of the caisson rested on sand, under other parts the sand had been washed out 4 or 5 ft. lower. The problem



PLAN AND SECTION OF ANNULAR PNEUMATIC CAISSON FOR REPAIRING CENTER PIER OF LITTLE ROCK, ARK., BRIDGE; ST. LOUIS, IRON MOUNTAIN & SOUTHERN RY.

now was to get an even bearing for the cutting edge before the caisson could be weighted down and the air turned on. The only feasible plan that presented itself was to fill up these low places with sacks of sand. Sand could be obtained near by on the bank of the river. The sacks used were of burlap, and as much sand was put in each as one man could conveniently carry. This was about 1.8 cu. ft. The sacks were carried on a flatboat or barge to the caisson, where they were slid or dropped into the water with as little disturbance as possible. The low places did not fill up very rapidly, the current carrying many of the sacks a distance down stream before they struck bottom. About 12,000 sacks were put in before a large enough proportion of the cutting edge had a support. About 30 or 40 ft. out of a total of 460 ft. of this cutting edge was still unsupported. On account of the large size of the caisson, and the impossibility of binding it into a firm, solid structure, great care had to be exercised to keep it from springing or getting in "wind." By observing the amount of water that each corner was drawing, one could easily see whether it was in wind or not.

The open space above the roof of the working chamber was now filled in with sand to a depth of about 4 ft., which was the amount of sand necessary to hold the cutting edge on the bottom when the air was turned into the chamber. It would not do to overload it at this time as the support was not uniform enough to keep it from being twisted and sprung. The cutting edge was 35 ft. below the surface of the water, which means that 35 x .43 = 15 lbs. of air per sq. in. are needed to force all the water out of the working chamber (.43 being the weight in pounds of a column of water 1 ft. high and having 1 sq. in. cross-section). The air, which was supplied by two compressors 1,200 ft. away on the shore, and was brought out through a 4-in. pipe, was now turned into the chamber and the water driven out. Men immediately went in through the lock, and with moist clay stopped up all the small leaks. There was no difficulty in finding these leaks, as the escaping air made a noise that showed where such openings existed.

The next work was to start the excavation. Although the cutting edge had a support most of the way around, the space between in the chamber was not so well filled up, and while in some places the bottom of the river was uncovered of water, in others the water was several feet deep. Only a dozen men could work in the chamber at first. The number was increased as fast as room was made for more till the number reached 18 or 20. The materials first encountered were sand, considerable of it being in the sacks before mentioned, and some old piles that had been broken off near the bottom of the river. These old piles were quite numerous and made rapid sinking an impossibility, as they had to be cut off a foot or two at a time. When it was possible, a hole was bored in with an auger, a piece of dynamite was put in and exploded with electricity. This would cut the pile off even with the hole.

There were two methods of getting the sand out—the methods being very similar, however. One was the "wet blow out," and the other the "dry blow out." Down through the roof of the chamber protruded the 4-in. discharge pipes, seven in all, placed at convenient intervals. These had cut-off valves in the ends that were in the chamber. The other ends were above the surface of the river. To the end in the chamber, a rubber suction hose, 4 ins. in diameter and 15 ft. long, was attached. On the other end of the hose was a nozzle with a 3-in. opening. This nozzle was placed down in the water and into the sand and the valve opened. The air pressure sent sand and water up at great speed. The "dry blow out" method was used when the materials, though not coarse, had to be loosened with shovel before being blown out. The material was put in piles, then when the nozzle was brought near and the valve opened, it would be drawn in and forced up and out. Stones 2 or 3 ins. in diameter were sent out in this way and hurled 300 or 400 ft. after leaving the upper end of the discharge pipe.

The cutting edge of the caisson was a 4 x 8-in. oak strip securely bolted to the timbers above. The 8-in. side formed the edge. Excavation under this edge had to be made uniform under all parts of it in order to keep the caisson level. When rock was reached the descent was of course slower. This rock was a shaley slate, soft in some places and as hard as granite in others. Its surface was very uneven. When it was first reached there were other parts of the cutting edge that had nearly 5 ft. to go before reaching it.

The work of excavation in the chamber was carried on night and day, the men working in three shifts of eight hours each. One of the shifts was composed entirely of negroes. Their work in this line was very nearly as good as that of the white men. They could not be depended on in an emergency, however. They lacked nerve. The pressure was not great enough to cause much of caisson disease or "bends." There were only two or three cases, and they were not serious.

The rock and coarse materials in the chamber were hoisted out in buckets through supply shafts. These shafts were three in number, placed on different sides of the caisson. They were 3 ft. in diameter. The lock used is known as the Moran lock. It is built for rapid handling of material, has large openings for equalizing the air, and doors that are operated by levers on the outside. The materials were raised or lowered in a bucket holding about 20 cu. ft. A derrick and hosting engine on a barge raised and lowered the bucket. The cable was woven smooth so that by using packing where it runs through the door of the lock it works air tight. When the material was close by the bottom of the shaft a bucket full could be taken out every five minutes.

Sometimes a method called "blowing" was resorted to to hasten the sinking of the caisson. This was to let the air out of the chamber rapidly, faster than the water would come in, till the pressure was reduced 10 or 15 lbs. per sq. in. This could be done when the cutting edge was down in sand or rock all the way around so that the water would be held back to a considerable extent, the result being as if a load of 10 or 15 lbs. per sq. in. had been suddenly added to the caisson. This method had to be resorted to with considerable caution as there was danger of opening up seams and joints to such a degree that the chamber would not hold air and the water could not be driven out again.

When the caisson was finally down into rock all around, the loose material was all carefully cleaned out and the "sealing up" process commenced. That consisted in filling the chamber with concrete. The concrete was mixed outside the caisson and taken in through the Moran lock. After filling every part of the chamber the air was kept on for a couple of days to allow the concrete to set.

The next thing done was to fill in the space between the new caisson and the old with concrete. This was done to a distance of about 30 ft. above the cutting edge. A solid ring of concrete now surrounded the old caisson, tightly bound in by the new caisson.

The conclusions that were reached in regard to the leaning of the pier were that the old caisson was not on rock all around, some parts being on sand, possibly as much as 2 or 3 ft. deep. Observations taken on the pier with a level showed the greatest movement to take place after high water in the river. The further conclusion was reached that this sand was being washed out gradually and the caisson would continue to lean till it came to a firm bearing. The new caisson with the concrete ring would put an effectual stop to any further washing out of this sand.

THE CENTRAL LONDON UNDERGROUND ELECTRIC RAILWAY.*

At last London is on the point of having an electric railway running along its greatest thoroughfare, and serving all classes of its population. The Central London Railway, which runs from Shepherd's Bush in the west to the Bank of England, the center and focus of the city, is certain of having an immense traffic, for along its entire stretch there is great business activity, and along its western half an immense residential population. If there is any place in the world where a deep tunnel railway can earn satisfactory dividends it is here, for the need of it is urgent, not only morning and evening to carry men and women between their offices and shops and their homes, but also at all hours of the day, for along the line of route the calls of business and pleasure are never hushed until long after midnight, and even then there is traffic enough to constitute a bustle in many a provincial town. A deep tunnel line is one that needs a heavy traffic for its success, for its cost is enormous. Upon the 5¾ miles between the termini of this railway there has been spent $15,570,000, at least that was the amount of the contract, and $620,000 will be needed annually to pay 4% on the amount. Four years have been spent on the construction, and the opening has been looked for with great eagerness, as upon the results of the working will depend whether we are to see a great extension of this method of transport.

As engineers we must view the new line with mixed feelings. We have cause to congratulate ourselves on its execution, and that London has always led the way in the matter of deep tunnel lines, each step in the progress having been worked out here, in consequence, in a great part, of the inventive ability and the great engineering skill of the late Mr. T. H. Greathead. At a time when we no longer monopolize the lead in problems of transportation, it is gratifying to think that in this particular department of the subject we still stand in the van. On the other hand, it is subject for mortification to know that practically the whole of the mechanical and electrical appliances comprised in the equipment of the line are of American design and construction. The engines, the generators, the converters, the locomotives, and the hoists were all made in America, and are the product of American brains. At the time the plant was contracted for, many of the parts were far larger than had been attempted before, and could only be safely undertaken by engineers or electricians who had a deep fund of experience to draw upon, and a large confidence in their own ability. Such experience did not exist in this country; all opportunities of acquiring it had been destroyed by legislation, which had subordinated private enterprise to municipal greed. Parliament allowed the capitalist to undertake the very difficult problems, while it debarred him from the easier ones on which he might have gained the experience he required. Consequently, when this railway was undertaken, those who were responsible for it felt that their only prudent course was to place their orders for equipment in the United States. There is ground for hope that we shall not be again found in quite so hopeless a position: British engineers are accumulating knowledge in respect to electric traction, and new firms, like the British Westinghouse Co. and the English Electric Manufacturing Co., are more American than the Americans in their desire to adopt the newest and the best of manufacturing processes.

The new line is, we believe, unique in that every station is placed upon an eminence, and hence the outgoing train is aided by gravity and the incoming train retarded.

*From "Engineering," London, June 29, 1900.

With stations placed at average distances of half a mile, the question of stopping and starting is of immense importance, seeing that the speed is determined by the rate of acceleration and deceleration. When approaching a station the train runs up a gradient of 1.66%, and immediately after leaving it descends one of 3.3%. This latter is equal to a pull of 74 lbs. per ton, and the effect of it is quite evident to a passenger in the train. In running into a station, energy equal to 100 HP.-minutes is stored in the train, ready to be expended on the down grade. The motors are thus relieved of a great deal of work, which would be otherwise be thrown upon them, and the general average speed is increased beyond what would otherwise be practicable.

The Central London Ry. runs from Shepherd's Bush to the Bank, a distance of 5¾ miles, the whole distance being in deep tunnel, at depths varying from 60 ft. to 90 ft. For the greater part of the distance the two tunnels are side by side, but near the General Post Office, where the road is narrow, one is above the other. Each tunnel is 11 ft. 6 ins. diameter, and has a cast-iron lining on the well-known system devised by Mr. J. H. Greathead. There are 13 stations on the line, and it is intended to cover the distance from terminus to terminus at an average speed of 14 miles an hour, the maximum speed being 25 miles an hour. Each train will consist of seven cars, designed to carry 336 passengers, and weighing, when loaded, 105 tons without the locomotive. The trains are to follow each other, at the busy hours of the day, at 2½ minutes intervals, and 28 locomotives have been provided to work the traffic. Each locomotive has two four-wheeled trucks, and weighs 97,000 lbs. It has four motors, one on each axle, of 117 HP., the armatures being built on tubes, afterwards forced on to the axles. The length over the body of the locomotive is 26 ft. 7 ins. and over the buffers 30 ft., the width being 7 ft. 8 ins. The armatures are built directly on to the axles, and hence the motors lie between the frames, quite low down. Over them is a deck, on the central portion of which is a very roomy cab, from which an excellent view of the road can be obtained. Forward and aft of the cab are resistances, placed under sloping covers, which give a wedge-shaped appearance to the ends of the locomotive. The coaches have been built partly by the Ashbury Railway Carriage & Iron Co. and partly by the Brush Electrical Engineering Co. They are entered at the ends, and have central passages, the seats being arranged both lengthwise and crossing; the lighting is most excellent.

The power for working the railway is generated in a very spacious house at Shepherd's Bush, and transmitted through the tunnels to three converting and distributing stations. There is a boilerhouse 148 ft. long by 87 ft. wide, containing 16 Babcock & Wilcox boilers, each having 3,580 sq. ft. of heating surface. The boiler plant has been laid out with the greatest regard to economy, the plant being supplied with Archbutt-Deeley water softeners, feed-water filters, and Green economizers. The coal is delivered on the ground by the railway trucks, and is dealt with entirely by elevators and conveyors; provision is also made for dealing with the ashes in the same way. Draft is afforded by two chimneys, 250 ft. high, and 10 ft. diameter inside. The engine room is 200 ft. long by 86 ft. wide, and contains six cross-compound Corliss engines, constructed by the E. P. Allis Co., of Milwaukee, U. S. A. Each engine has cylinders 24 ins. and 46 ins. diameter, and 48 ins. stroke, and makes 94 revolutions per minute. It is designed to give 1,300 I. HP., with an increase up to 1,900 HP. on overload. There is an emergency governor in addition to the governor controlling the Reynolds-Corliss gear, which cuts the steam off completely when the speed reaches 105 revolutions. The steam is first passed through a separator, and after passing through the high-pressure cylinder it is drained and slightly superheated in a reheater. The exhaust steam is condensed in a jet condenser, the condensing water being cooled in four Barnard-Wheeler cooling towers, each served by four double fans driven by Belliss engines.

Upon the crankshaft of each engine is a three-phase alternating-current generator. This shaft is 22 ins. diameter in the wheel seat and 20 ins. in the journals, which are 36 ins. long. There is a flywheel 18 ft. in diameter, weighing 100,000 lbs. The armature is stationary, and surrounds the revolving field. There are 32 magnet cores in the field, the weight of which is 34,000 lbs., while the complete armature weighs 48,000 lbs. Each generator has an output of 850 K-W. at 5,000 volts and 25 periods per second. The commercial efficiency at full load is 95.5%, and at overloads it is upwards of 96%. There are four six-pole exciters to energize the fields of the main generators, each is of 50 K-W. and 125 volts, and is driven direct at 450 revolutions by a compound tandem Allis engine, with cylinders 9½ ins. and 15 ins. in diameter, with a stroke of 6 ins.

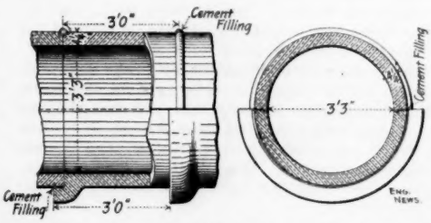
At the north end of the generating station there is an elevated switchboard on a gallery, comprising twelve double panels of white marble bolted to angle-iron uprights. This board is fitted with the usual instruments, and with very ingenious switches and interlocking gear, which we described in our previous articles. There are four outgoing mains from the switchboard, to carry the current at 5,000 volts pressure to three sub-stations, situated respectively at Notting-hill Gate, Marble Arch, and the Post Office. Each main comprises three copper conductors insulated with paper. These mains were constructed by the National Conduit & Cable Co., and have each a total copper cross-section of 0.1875-in. between the power station and Notting-hill Gate, and 0.125 sq. in. between Notting-hill Gate and Marble Arch. Two of the cables end here, and the other two go forward to the Post Office, where the high-tension line terminates. Altogether there are 19 miles of cable, weighing 78.4 tons. As already mentioned, there are three converter sub-stations. Each is placed at the bottom of an elevator shaft, and is situated below the level of the station platform, occupying, at Notting-hill Gate, a chamber 30 ft. diameter and 21 ft. high, and at the other stations two chambers, each 23 ft. in diameter by 15 ft. high. At each of these sub-stations the current received at 5,000 volts is first transformed, in three transformers, to 330 volts, and is converted by a rotary converter to 500 volts for delivery to the third, or contact, rail on the railway. For this purpose there are provided seven transformers, two rotary converters, switchboards, and blowers. Each transformer has a capacity of 300 K-W. at a pressure of 330 volts on the secondary side, and the transformers are coupled up on the delta system, on both the primary and secondary sides. They are ventilated by blowers, made by the Buffalo Forge Co., and driven by three-phase induction motors of 6 HP.

The rotary converters are rated at 900 K-W output—1,800 amperes at 500 volts. They have 12 poles, and run at 250 revolutions per minute; the nominal potential difference between the collector rings is 330 volts. The armatures are 7 ft. diameter outside, the inside diameter of the core being 5 ft. 2 ins. They are of the drum type, wound with bar conductors. The commutator is 54 ins. diameter, with 576 segments, and runs beneath 12 sets of carbon brushes. The total weight of the armature is 24,800 lbs., of the magnet frame 19,500 lbs., and of the whole machine 48,350 lbs. The current from the converter is delivered to a third steel rail, of 85 lbs. per yd., fixed between the other two rails, and at a height of 1¼ ins. above them. This third rail is carried on stoneware insulators spaced 7½ ft. apart. The current is picked up by the locomotive by two heavy cast-iron shoes; it passes through an automatic circuit breaker and switch to the controller, and thence through the motors to the track rails. These are of 100 lbs. weight, of bridge section, and are bolted to longitudinal sleepers.* They are double-bonded with Brown bonds, having a total cross-section of 0.62 sq. in.

The motors on the locomotives are of the series-wound four-pole ironclad type. The frames are of soft cast steel, and the magnets are wound with copper strip. The armature is of the series-drum type, with 366 bars, 0.6-in. by 0.1-in., and weighs, without the axle, 3,000 lbs.

The engineers of the line are Sir Benjamin Baker and Mr. Basil Mott, and the contractors, the Electric Traction Co., The British Thomson-Houston Co., as sub-contractor, has acted under the advice of Mr. H. F. Parshall.

*Engineering News, April 12, 1900.



A 39-in. Concrete Pipe Sewer at Cookstown, Ireland:
Henry Shillington, Engineer.

A 39-IN. CONCRETE PIPE SEWER AT COOKSTOWN, IRELAND.

A length of 1,854 ft. of 39-in. concrete sewer was recently built at Cookstown, Ireland, with Mr. Henry Shillington as engineer. From a somewhat lengthy illustrated description of this work, published in the London "Surveyor," for May 25, 1900, we have prepared a brief description giving the most essential facts.

The sewer or culvert was an extension of a brick sewer of the same interior diameter, built to enclose a stream into which the sewage of the town is discharged. The location of the sewer being principally in either a "very shifty, sandy stratum, or else through rock-bed (principally the former"). Mr. Shillington decided to use a concrete pipe in two sections, as shown by the accompanying illustration. It will be seen that the lower section has flanged hub and socket joints, while the upper section has butt joints, with provision for cement calking in the lower and a bond of cement in the upper section. Longitudinally there is a tongue and rebate joint.

The sections were made in 3-ft. lengths, net, on molds covered with zinc sheeting. This covering gave rise to the greatest difficulties encountered in the work since:

> A very slight shrinkage of the wood, joined with the hard rubbing on the concrete, which seemed to extend the metal, resulted in buckling into perceptibly longitudinal ribs, so that the sheets had to be periodically lifted and adjusted. Of about 1,400 sections made only five were broken, two of which were repaired.

At the start an outer as well as an inner mold was used, but the outer mold was dispensed with and the concrete placed on the mold designed to form the inner surface, "as dry as possible and hammered tightly as the work proceeded."

As to the cost of the work, Mr. Shillington has the following to say:

> The cost of making has not been quite £1 per lin. yd., and the total cost, laying and all included, will not be quite 30s. per lin. yd. Had it been done in earthenware pipes, I estimate it at about 55s. per lin. yd. In brick work in cement it is difficult to say what it would have been, owing to the well-known character of the ground passed through— i. e., shifting sandy soil.

According to these figures the cost of making and laying was about $2.30 per lin. ft.

In our issue of Oct. 21, 1891, we published designs for concrete sewer pipe, made on somewhat similar plans as this, but of different cross-section, patents for which were then controlled by the Waring Sewer Pipe Co., of Newport, R. I. We do not know to what extent, if any, the company introduced the pipe. Cement pipe sewers of various shapes and sizes have been made in this country for years past, and concrete sewers have been constructed in the trench, notably at Reading, Pa., and elsewhere under the Ransome system.

A NEW RAILWAY IN FORMOSA is reported upon by U. S. Consul Mr. J. W. Davidson, of Tamsui, Formosa. The proposed line will run from Taihoku (Taipeh) to Tamsui via Maruyama, Shirin, Hokuto, and Kantau. Maruyama is a picturesque park on the Kelung River, much frequented by Japanese merrymakers. Hokuto (Pak-tau) is a village at the entrance of the well-known North Formosa sulphur district. There is an excellent Japanese inn here, and the sulphur springs provide hot mineral baths, healthy and delightful. The Japanese have recognized the value of the place as a sanitary resort, and extensive barracks and bath houses for the troops have been erected. Beyond the springs lies a gorge reeking with sulphurous fumes. The ground appears to be but a thin, ashy crust, vegetation does not exist, the rocks are burnt out and ash like, and sulphur has permeated both rocks and earth. To obtain the maximum of benefit from the new road, the trains must run frequently, and, that this may be possible without too great expense, the cars will be small and the locomotives light. The gage will be 3 ft. 6 ins., the same as the main line; but only 36-lb. rails will be laid. The construction of 13 bridges will be required, but only two of them are of any considerable size. In building this line, the materials from the old Chinese Kelung and Teckcham lines, which have now been almost entirely replaced, will be utilized. There are three or more old 25-ton locomotives in good order, a sufficiency of rails, and nearly all the required bridge ironwork now in possession of the railway office. There is no difficult engineering work required in the construction of the road, the maximum grade being but 1% and the curves very light. The total length of the new line as surveyed is 13 miles, and it is expected that trains will be running within a year. The cost of the line, exclusive of the materials referred to above, is estimated at $210,000. With the railway now being constructed through the island to Takow, and the line just described running across the north of the island from Kelung to Tamsui, the government will have completed the system of railways most required. A line from the west across the mountains to the east coast would be of great political value, but it is doubtful if it would ever be profitable, considering the cost of the difficult engineering work which the construction would necessitate. In connection with the railway building through the island, six locomotives, considerable general rolling-stock material, 60 miles of 60-lb. rails and fastenings, and 400 tons of bridge work will be shortly purchased by the railway office. There are at present four large Baldwin locomotives here, giving splendid satisfaction, though the chief engineer informs me that there are very few Formosa trains sufficiently heavy to obtain full value from them, and the six locomotives now desired are to be lighter and consume less coal. Although the specifications for the new engines will call for some parts of American design, the general type will be more in conformity with the English machine; and, unless home manufacturers are prepared to follow the specifications, the order will probably go to England. The rails and most of the bridge work are, it is reported, to come from the United States.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

We publish in this issue a description of a triple-expansion high-speed engine installed in an electric-lighting station in Vienna, Austria, which possesses many features of interest, to one of which we desire to direct especial attention.

This feature is the method adopted for governing, which is a combination of the variable cut-off with throttling of the steam supply. For moderate variations of load, the governor acts on the variable cut-off alone. When the load becomes so light, however, that the cut-off would become too short and the ratio of expansion too great for good economy, the governor begins to close the throttle-valve. The economy of the engine at light loads with this method of governing is superior to that obtained when the automatic cut-off is the sole reliance for regulating the speed.

The steam in passing through the throttle-valve undergoes free expansion, increasing in volume and decreasing in pressure. Saturated steam of a high pressure is changed into superheated steam of a lower pressure. This steam passes through the engine with much less condensation than would the same amount of steam admitted to the high-pressure cylinder and cut-off earlier in the stroke.

With a very short cut-off in the high-pressure cylinder, and consequently high ratios of expansion, it often happens in non-condensing engines that the steam pressure is the low-pressure cylinder may fall below the atmospheric during part of the stroke. Even where a condenser is used, the low-pressure piston may do little or no work, or even negative work during part of its stroke, and the condensation under such conditions is very great.

This point has often been brought out in connection with marine engine working. The Chief Engineer of the U. S. S. "Yosemite" during the Spanish war, Prof. M. E. Cooley, has stated to us that when running at low speed with that ship extreme care was necessary in order to prevent condensation in the low-pressure cylinder from assuming proportions threatening the safety of the engines.

Throttling at very light loads instead of further reducing the point of cut-off goes far, as above pointed out, to reduce this evil. This method of governing is almost unknown in this country, but it is widely used in Europe, especially on high-speed multiple-expansion engines, and it is believed to give superior results, in the case of a variable load, both as regards smoothness of working and all-day steam economy.

TESTS OF STREET CAR BRAKES BY THE NEW YORK RAILROAD COMMISSION.

The most important and exhaustive series of tests of street car brakes ever undertaken was made last year by the New York Railroad Commission; and their results have just been made public in a pamphlet of 60 pages, accompanied by plates showing the autographic records taken during the tests. Copies of this pamphlet can be obtained, we presume, by addressing the office of the New York Railroad Commission at Albany. In the present article we shall attempt to summarize the main results reached by these tests, and the most important lessons to be drawn from them.

These tests, which were briefly described in this journal while they were in progress, were made on the Lenox Ave. line of the Metropolitan Street Ry. Co. in New York city. The track chosen for the tests has a very slight grade (8.8 ft. per mile), and is laid with 90-lb. girder rails with 2-in. head. The line is a double track one, operated by the electric, underground conduit system. The cars used were the Metropolitan company's standard 8-wheel cars, weighing 20,816 lbs., equipped with Brill "maximum traction" trucks, with 30-in. and 20-in. wheels, and a total wheel-base of 17 ft. 6 ins. Brake shoes were applied to all wheels.

There were 26 applications by brake manufacturers and inventors to take part in the tests; and 16 companies actually equipped cars and had their apparatus tried. Of these, 4 were air brakes, 4 electric, 3 hand-power, 2 friction, and 2 were combined track and wheel brakes. The different brakes are described as follows in the official report:

Air Brakes.

The reliability of the air brake has been thoroughly established by its use on steam roads. A large number of them are now used on electric cars, and, with proper inspection and care, the air brake, as applied to electric cars, is a reliable, powerful, quick and easily controlled means of applying the braking power to a car wheel. Four systems of air brakes were submitted and tested. All were similar, so far as relates to the use of air under compression in a cylinder, to operate a piston from which, through levers, the power was transmitted to the brake shoes. They differed in the method of compressing the air and applying it to the piston.

The G. P. Magann Air Brake Co. presented what is known as a storage air system, in which there is an air compressor and reservoir located at the powerhouse or some central point on the street-car system. This reservoir is charged with air usually compressed to 300 lbs. pressure. The car is equipped with two storage reservoirs, which are charged in a few seconds from the stationary reservoir at 300 lbs. pressure. By means of a reducing valve this pressure is reduced to 50 lbs., at which pressure the air enters an auxiliary reservoir, from which it is controlled, to the brake cylinder by means of the engineer's valve, in the usual manner. There are some special features in the construction and operation of this valve. The storage equipment of cars is calculated for 300 stops, which is sufficient for ordinary car operation; when necessary this capacity can be increased.

The Christensen Engineering Co. presented what is known as the straight-air system, which consists of a reservoir, an electric motor compressor, an automatic regulator which governs the operation of the motor compressor; an engineer's valve and the usual brake cylinder. In this system, as its name implies, the compressed air passes direct from the reservoir to the brake cylinder, there being no auxiliary reservoirs or reducing valves between the pressure reservoir and the brake cylinder. All of this apparatus, with the exception of the controller, is placed under the car. There are a number of special features in the construction and operation of the system as presented by this company.

The Standard Air Brake Co. presented an automatic air-brake system, consisting of an electric motor-driven compressor, a storage-pressure reservoir, a motor controller, brake cylinder and engineer's valve. This system is similar to the one described above, except that there are a number of special features in construction and operation in which the two systems differ; the general principle of compressing and applying the air is, however, the same.

John E. Reyburn presented an air-brake system similar to the two last described, except that the compressor was operated mechanically instead of by an electric motor. This compressor was worked by the motion of the car axle, which was transferred to the compressor by means of friction disks or wheels, one of which revolves with the axle, the other being fast on the compressor shaft. These were placed in such position that they made firm frictional contact. These friction disks are thrown into contact and released by compressed air from the reservoir. After the air has been compressed in the cylinder the operation is the same as usual in air-brake systems.

Electric Brakes.

There were four electric brakes tested. The only electric brake which is at present used to any extent by electric railroads is the one presented by the General Electric Co. The development of the electric brake up to the time of this test was mostly confined to that company.

The Electric Selector and Signal Co. presented an electric or magnetic brake, operated by the trolley current. This brake consisted of a series of magnets, the armatures of which are at varying distances from the magnets, all mounted loosely on the same rod and in such a manner that the attraction of the armature nearest to the core carries with it the armature next in distance from its core to a point of greater magnetization, and so on, each armature acts upon the next, thus creating a long and powerful pull. These armatures are arranged on a rod which forms a part of the ordinary brake rod. This brake can be applied to the ordinary spindle hand brake. The movement of the brake handle sets the electric brake in operation, and this movement can be continued, setting up the shoes by hand without interference from the electric portion of the brake, so that in case of failure of the current the brake can be set by hand. The hand brake is under test at all times when the electric brake is used, thus insuring it being in working condition, in case of failure of the trolley current. A maximum of five amperes of current is used in the operation of this brake.

The General Electric Co. presented an electric brake which is in use on several electric roads in this state. The construction and operation of this brake is as follows: Each motor is fitted on the commutator end with a cast-steel yoke provided with two horns, which project on each side of the axle and support the brake shoe. This shoe is 26 ins. in diameter, and consists of two cast-iron halves, a crescent-shaped slot being cast in each half, which holds the energizing coil. A cast-iron wearing plate is bolted to the face of the shoe and is provided with slots directly over the slots in the main shoe casting. These slots are filled with an antimony-lead alloy, which thoroughly protects the coils from injury and at the same time increases the smoothness of the braking. The disk, with which the brake shoe is drawn into contact, when energized, is cast as a part of the car wheel, and is merely a finished surface on the inside of the wheel. The wear on the brake shoes is taken up by means of adjusting screws on the brake support. The braking is accomplished in the usual manner, by converting the motors into generators and passing the current thus generated through the brake shoes and a regulating resistance. With this method of braking it is immaterial whether the plow is in contact with the conduit rails, or the trolley wheel with the wire, or not, as the braking power is obtained from the momentum of the car. The braking effort is due partially to the back torque of the motors acting as generators and partially to the friction between the shoes and the wheel disks, and is about equally divided between the two. The controller has a single operating cylinder, which is rotated in one direction for power and in the opposite direction for brake. The brake shoe on each axle is directly in series with the armature of the motor on the same axle. If either shoe tends to lock, due to the too rapid application of the brake, the axle will cease to turn, or, at least slow down, with the result that the armature in series with the shoes ceases to generate as great a voltage as the armature of the other motor. The natural result is that the current will pass through the locked shoe in the reverse direction and demagnetize it, allowing it to release. The shoes are demagnetized in the usual manner, by shunting a portion of the current on the first power point through them in the reverse direction, thus allowing them to release and drop away from the disk. The location of the apparatus, of course, is arbitrary, the cables having taps located at the proper points for connection to it.

Two other electric brakes were tested, but as they did not meet the requirements of the test, no description of them is given.

Hand Power Brakes.

Three systems of hand power brakes were tested.

The Sterling Supply Co. presented a hand power brake which is quite extensively used, the Metropolitan Street Ry. Co. of New York city using it exclusively. It consists of gear wheels applied to the ordinary spindle, which multiply the power applied to the brake handle. This brake is equipped with a double brake chain.

Martin H. Vogel presented a newly-devised and effective hand power brake. It is constructed by applying eccentric [illegible] wheels to the ordinary brake spindle, so that the [illegible] movement of the brake handle brings the eccentric [illegible] wheels in such position that their speed is multiplied [illegible] their power reduced. As the revolution of the spindle continues, this condition changes with the movement of the brake handle to one of multiplied power and reduced speed. This results in quick action in taking up the slack [illegible] the brake chain, and increased power on the final [illegible]ement, when power is required to set the shoe against [illegible]face of the wheel. This brake is devised and intended [illegible] the double chain connection, from the drum to the [illegible]ke levers.

The Sauvage Street Car Brake Co. presented a novel [illegible]ke system, constructed on the principle of a wedge [illegible]cing against a wheel. The forward brake shoe is at[illegible]ched to a double wedge, which is formed of two wedges [illegible]ted at their thin edges. Back of this is a roller con[illegible]ected to a thrust bar, reaching from wheel to wheel, the [illegible] for the second wheel being attached to the further [illegible] of this thrust bar and acting directly upon the wheel. [illegible]is is the simplest form of the brake, but in double [illegible]cks with wheels of different diameters carrying differ[illegible]ent weights, a device must be used whereby the pressure [illegible] the brake shoes is made proportional to the weight car[illegible]ried on the respective wheels. The further end of the [illegible] thrust bar is connected by ball joint with a vertical lever, which carries the brake shoe for the little wheel, the [illegible]elative pressure on the two shoes being determined by the relative length of the lever arms. The application of the brake consists in raising or lowering the wedge between the roller and the revolving wheel. The effect of this is to move the shoe towards the wheel until it comes in contact with the revolving surface. As soon as this contact begins, the friction between the shoe and wheel tends to tighten the brake. If the wheel is turning upward and the wedge is moved upward, the friction on the wheel will tend to move it further upward and increase the pressure; if the wheel is turning downward and the wedge is moved downward, the friction on the wheel will tend to move it further downward and increase the pressure. The object of the double wedge is to have a brake which will act on wheels turning in either direction. The only difference in the connections used in this brake and those of the ordinary hand brake consists of the two arms, one placed on each side of the thrust bar. These arms have slots in them in which a pin, passing through the center of the wedge, rests. As these arms are moved up and down by the motorneer they carry the wedge with them, and suitable connections enable the motorneer to move the wedge up and down between the thrust bar and the wheel at his discretion.

Friction Brakes.

There were two friction brakes tested. This class of brake is used on several of the roads in this state.

The Peckham Motor Truck & Wheel Co. presented a friction brake known as "The Price Brake," which consists of a friction device placed on one of the axles of the car. This friction is in the form of two disks, one of which revolves with the axle, the other being attached to a loose collar or sleeve which is placed on the axle. To this sleeve a chain is attached and extends to the sway bar of the brake rigging. These disks are brought together by leverage operated by the motorman; this imparts the motion of the axle to the loose sleeve, winding up the chain and in this manner setting the shoes.

The J. G. Brill Co. presented a friction brake in principle similar to the one described above, but differing from it in some of the details of construction and operation.

Track and Wheel Brakes.

The Devlin Street Car Brake Co. presented a track and wheel brake. In the construction of this brake there is a brake head with two shoes, one fitted for the wheel, the other on the bottom of the head to fit the rail. The head is suspended by springs in such a manner that when the shoe is applied to the wheel the movement of the wheel causes the brake in front of it to be forced down, bringing the track shoe into operation. This shoe also acts as a fender, preventing anything from going under the wheel. This brake is operated by friction power, the usual friction disks being used.

TABLE II.—Showing standing of Brakes Based on the Formula, and Per Cent. of Rating Based on the Average Stops; also Per Cent. Deducted from this Standing for Skidding of Wheels, and the Per Cent. of Rating after Making this Deduction.

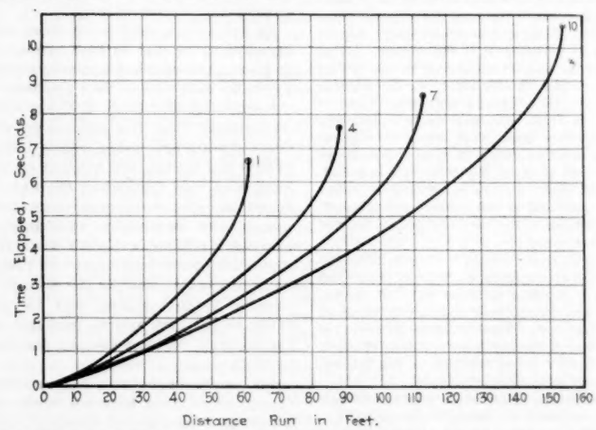
Name of Company.	Formula $\frac{W S^2}{d}$.	Average stop at all speeds, ft.	Per cent. Rating based on average stop.	Per cent. Deducted for skidding of wheels.	Per cent. Rating after deduction.
Electric Selector & Signal Co.	66,197	58.83	100.00	1.7375	98.26
Sterling Supply & Mfg. Co.	58,073	69.16	87.73	0.875	86.86
Peckham Motor, Truck & Wheel Co.	64,410	66.71	97.30	10.70	86.60
G. P. Magann Air Brake Co.	54,853	73.22	82.86	4.00	78.86
Devlin Street-Car Brake Co.	54,424	78.15	82.21	6.20	76.01
Standard Air Brake Co.	49,907	82.92	75.39	5.75	69.64
General Electric Co.	45,630	104.45	68.93	0.225	68.71
Vogel Brake Co.	44,300	88.46	66.92	0.875	66.05
Christensen Air Brake Co.	44,322	96.67	66.95	2.00	64.95
J. G. Brill Brake Co.	44,545	92.08	67.29	4.35	62.94
Safety Appliance Co. (tested at 8 miles only)	38,290	96.10	57.84	1.0625	56.78
Sauvage Brake Co.	36,600	107.07	55.29	0.6875	54.60
Price, Darling & Co. (tested at 8 and 12 miles only)	31,803	45.27	48.04	0.1875	47.85
J. G. Reyburn Brake (tested at 8, 12 and 15 miles only).	29,547	80.40	44.63	0.25	44.38
Columbia Car, Light & Brake Co.	29,325	132.80	44.30	0.225	44.08

The plan of the tests was to make stops with each brake at speeds of 8 miles, 12 miles, 15 miles and 16 miles per hour, the tests at the highest named speed being made both with and without the use of sand, and no sand being used in the lower speed tests. It was originally intended also to make tests at 20 miles per hour, but the motors could not bring the cars to that speed.

To record the results of the tests, an automatic recording apparatus was devised. A pen was made to trace a curve on a diagram in which the distances run by the car were the abscissas and the times from the signal for brake application were the ordinates. A sample sheet is shown herewith. It will be seen that the effectiveness of the braking action at any point is indicated by the extent to which the curve at that point departs from a straight line.

Besides this automatic record, observations were made of the skidding of wheels. The tests were all made in clear dry weather for the sake of uniform condition of the rail; the stops made are, therefore, considerably better than could be counted upon in average service. The general results for all brakes are summarized in Table I., which is taken from the report, with the exception of the right-hand column, which has been added by us to give an idea of the amount of skidding of wheels caused by the different brakes.

It will be seen by this table, and still more by the detailed log of the tests, that there was a great deal of skidding of wheels. Some of the brakes made hardly a stop without some of the wheels sliding more or less. The obvious conclusion is that the brake leverage was excessive for the weight of the cars, and that emergency stops with brakes adjusted for such high pressures on a wet and greasy rail would result in all wheels sliding most of the distance.



SPECIMEN AUTOMATIC RECORDS OF STOPS MADE IN NEW YORK TESTS OF STREET CAR BRAKES.
(Tests of Christensen Air Brake at Speeds of 8, 12, 15 and 16 Miles per Hour.)

To compute the relative efficiency of the various brakes, the commission took the average results of the tests and compiled with them the percentage of efficiency of the different brakes, using as a formula

$$\frac{W S^2}{d},$$

in which W = the net weight of the car and its load; S is the speed at which the brakes are applied, and d is the distance run before stopping. In other words, they divided the kinetic energy of the car, in each case, by the distance which it ran before stopping. From this percentage they deducted an allowance which was assumed to represent the loss in efficiency due to skid wheels. Table II. shows the results of this calculation.

It will be understood that the relative standing shown in this table is obtained by direct computation of the results of the test. Manifestly, however, many other qualifications must be taken into account in determining the availability of a brake for regular service. The Board of Railroad Commissioners takes this matter up also, and we reprint its final conclusions as follows:

A letter, dated April 4, 1900, was sent to each of the contestants in the brake test, requesting them to furnish an approximate price for which they would sell their brakes complete in ten-car lots, free on board, at their

TABLE I.—Showing Average Stops made with all Brakes Tested at 8, 12, 15 and 16 Miles per Hour, and at 16 Miles per Hour with Sand.

Name of brake.	Speed per hour—8 miles. Ft.	Secs.	12 miles. Ft.	Secs.	15 miles. Ft.	Secs.	16 miles. Ft.	Secs.	16 mls. with sand. Ft.	Secs.	Skidding of wheels.
Peckham Mofor, Truck & Wheel Co.	42.41	7.03	59.52	6.44	70.50	6.87	81.25	7.43	79.91	7.51	Much.
Devlin Street-Car Brake Co.	54.08	7.38	65.80	8.86	92.36	9.58	93.63	9.51	84.91	7.98	Much.
Christensen Air Brake Co.	56.86	6.20	88.25	7.88	113.80	8.60	130.75	9.74	93.70	6.63	Little.
Standard Air Brake Co.	54.19	5.79	76.08	5.48	86.83	7.32	104.47	8.48	93.04	6.58	Medium.
General Electric Co.	45.00	5.34	111.02	8.95	114.86	8.32	134.72	8.62	116.66	6.58	Little.
Columbia Car Light & Brake Co.	65.86	6.16	99.94	5.46	139.50	7.30	155.08	7.70	203.66	7.55	Little.
Sauvage Street-Car Brake Co.	46.11	4.00	78.58	5.67	129.16	8.50	138.27	8.60	143.25	7.31	Medium.
J. G. Brill Co.	35.11	3.16	67.83	6.12	121.88	7.50	108.44	6.22	127.16	7.47	Much.
Safety Appliance Co. (no sand test made)	40.27	3.15	68.36	4.54	135.11	5.92	140.69	6.07	.....	...	"
Vogel Brake Co.	50.86	7.56	72.83	7.86	92.11	9.62	119.94	10.56	106.58	9.35	"
G. P. Magann Air Brake Co.	42.72	6.75	56.80	7.33	81.80	9.12	95.66	9.17	89.16	8.70	"
Price-Darling (only one test)	45.27	7.23	.....	...	.....	...	.....	...	.....	...	"
Sterling Supply & Mfg. Co.	41.50	6.99	57.00	7.91	75.27	9.59	81.41	9.35	90.66	9.45	"
Electric Selector & Signal Co.	38.75	7.71	50.00	7.95	60.02	8.28	72.33	9.35	73.08	8.92	"
J. E. Reyburn (no test after 12 miles)	66.80	7.17	94.00	8.55	.....	...	.....	...	.....	...	"

The per cent. deducted for skidding wheels is based on the following values:

	Skidding, 15 ft. or more.	10 to 15 ft.	5 to 10 ft.
One large wheel	0.25	0.125	0.0625
One small wheel	0.125	0.0625	0.05125
Large and small wheels	0.45	0.225	0.1125
All wheels	1.00	0.75	0.50

factory. The following list shows the result of the answers to this request:

The Peckham Motor, Truck and Wheel Co.	$125
The J. G. Brill Co.	85
The Standard Air Brake Co.	350
M. H. Vogel	30
The Sterling Supply & Manufacuring Co.	35
The Devlin Street Car Brake Co.	100
J. E. Reyburn	175
Price, Darling & Co.	200
The Electric Selector & Signal Co.	180
The Sauvage Street Car Brake Co.	100
The G. P. Magann Air Brake Co.	200
The General Electric Co.	585
The Christensen Engineering Co.	350

* * * * * * * * *

The board has devoted much time to this test; and, while nothing has been brought forth that will revolutionize the manner of stopping a car, the opportunity is afforded to present to railway officials and to the public facts and figures showing what the best appliances known today can do in the matter of stopping a car quickly. While these results are very satisfactory, there is still room for much improvement, and the board feels that its action in holding a public test will result in still further improvements in brakes or in new inventions which will reduce the distance within which a car can now be stopped.

In this state there are several classes of electric roads all using the same motive power, applied in the same manner; but, as far as liability to accidents in their operation is concerned, they are as separate and distinct as steam and electric roads. There are roads operated in the smaller cities with single-truck cars, weighing from six to eight tons, at a maximum speed of from 15 to 18 miles per hour. The suburban roads, between the smaller towns and between the smaller cities and summer resorts, operate the same class of cars, on which it is the custom, during summer holidays and on special occasions, to use trailer cars. In the larger cities double-truck cars, weighing from 10 to 17 tons, are operated at a maximum speed of 25 miles per hour. On some suburban roads, connecting large cities and extending from these cities to summer resorts, double-truck cars, weighing 23 tons and equipped for a maximum speed of 50 miles per hour, are operated. A brake which would fulfill all the conditions of safety for the smaller cars, operated at the lower rates of speed, might be entirely inadequate for controlling the heavier cars, operated at higher speed.

In the report of the electrical expert is given a list of the brakes in their order of standing, as a result of the actual mechanical test. This standing is based only on the result of the curves taken on the test and the skidding of wheels as noted at that time. This standing, however, is modified by adding to or deducting from it points of merit or demerit based on the following features on the brakes:

First.—Reliability and simplicity of system.

Second.—Liability of brakes to act when they should not.

Third.—Ease of operation by the ordinary motorman.

Fourth.—The cost of the equipment and maintenance.

After carefully considering these various points in each system, and adding to or taking from the mechanical standing of the different brakes, as given in the report of the electrical expert, the board gives the several brakes the following final standing in the order of their respective merit:

The Electric Selector & Signal Co.
The Peckham Motor, Truck & Wheel Co.
The Sterling Supply & Manufacturing Co.
The G. P. Magann Air Brake Co.
M. H. Vogel.
The Devlin Street Car Brake Co.
The J. G. Brill Co.
The Sauvage Street Car Brake Co.
The Standard Air Brake Co.
The Christensen Engineering Co.
The General Electric Co.
J. E. Reyburn.
The Columbia Car Light & Brake Co.
Price, Darling & Co.
The Safety Appliance Co.
Bach & Schlegel.

After a careful consideration of the whole subject of brakes for electric cars, the board has determined that, except in special cases, where the liability to accident is very remote, the ordinary single chain and spindle hand brakes, now generally used, should be replaced by the brakes made by one of the following manufacturers, or any other, which, in the judgment of the board, is hereafter shown to be equally efficient:

Air Brakes.—The G. P. Magann Air Brake Co., The Standard Air Brake Co., The Christensen Engineering Co., J. E. Reyburn.

Electric Brakes.—The Electric Selector & Signal Co., The General Electric Co.

Friction Brakes.—The Peckham Motor, Truck & Wheel Co., The J. G. Brill Co.

Hand Power Brakes.—The Sterling Supply & Manufacturing Co., M. H. Vogel The Sauvage Street Car Brake Co.

Track and Wheel Brakes.—The Devlin Street Car Brake Co.

A large proportion of the cars operated in this state are now equipped with the ordinary spindle hand brakes, and the board realizes that to make a change on all the cars at once might be a hardship for some of the companies. The board will, therefore, consider the question of requiring a percentage of them to be changed each year until all the ordinary spindle hand brakes have been replaced by some more efficient brake.

Turning now to Table I., which will be recognized as containing the meat of the results obtained in the tests, the first thing that impresses one is the surprisingly long distance which the cars ran before they were stopped, especially at the lowest speeds. A car running at 8 miles per hour has not a large amount of stored energy. Its "height due to velocity," or the vertical distance it would rise if its forward motion were instantaneously altered to upward motion and its inertia were utilized to oppose the attraction of gravitation, is only a little over 2 ft. Yet in the tests at these speeds, the cars ran 35 to 65 ft. before they were stopped by the brakes. In other words, if we suppose the brakes to have exerted a uniform retarding force, they were equivalent in the one case to an opposing grade of only 2 ft. in 35 ft., or say 6%, and in the other case to 2 ft. in 65 ft., or about 3%. Now we know very well that brakes hold and control cars on grades much steeper than this, and as the brake was certainly doing effective work near the end of the stop when the wheels frequently began to slide, it is certain that it had little effect on the car during the first part of the distance recorded as "length of stop."

So far as our studies of these tests extend, this appears to be due to two causes: first, the delay in getting the brakes applied; second, their failure to "take hold" when first applied.

Regarding the first of these causes, it will be understood that the automatic record on which these results are based, really begins to be traced before the brakes are applied to the wheel. What happened was that when the car reached a given speed an electric circuit was closed, setting in motion the recording machinery, and simultaneously ringing a bell to warn the motorman to throw off power and apply the brakes. It requires an appreciable time for the motorman to hear and respond to this signal, and for the brake apparatus to get into action, perhaps as much as 1 or 1½ seconds, or long enough for the car to run 10 to 20 ft.

Still more important, however, is the low coefficient of friction between brake shoe and wheel when the brake is first applied. It appears to take one or two revolutions for the brake shoe to come to a bearing and exert an effective hug on the wheel. This corresponds well with the experience in brake tests and brake shoe tests on steam railways. If we remember rightly, this low coefficient of friction at the first application is especially noticeable where the brake shoes are not thoroughly worn to the wheel. Nothing is said on this point in the report; but as all the cars were newly equipped for the tests, it is quite probable that the brake shoes had not been thoroughly worn to the wheels.

This "delayed effectiveness" of the brakes is apparent also when we compare the results obtained at different speeds. The energy in a car moving at 16 miles per hour, which must be absorbed by the brake shoes before it will come to rest, is four times as great as in a car moving at 8 miles per hour. Yet the distance run before stopping from the 16-mile speed in these tests was frequently little more than twice the distance required to stop from the 8-mile speed.

It will be apparent from the above conclusions that the street car brakes which were tried in the above tests, which include practically all the improved brakes now on the market, are far from having atained theoretical perfection. A perfect brake would be instantaneously applied, and would, from the moment of its application until the car came to a stop, exert a uniform retarding force upon the car as great as is possible without sliding the wheels.

On a dry rail, such as was had in these tests, the coefficient of friction between wheel and rail can hardly be less than 0.2. Making all allowances for variation in condition of rail, in load applied to wheel due to rocking of cars, tipping of trucks and other causes, a brake shoe retardation of 12% of the weight on the wheel ought not to cause sliding of the wheels, and be quite possible of practical realization. This is equivalent, of course, to a retarding force applied to the whole car equal to 12% of its weight, and such a force would stop a car from an 8-mile speed in 17 ft., from a 12-mile speed in 40 ft., or from a 16-mile speed in 68 ft.

It must be plain to any one who carefully studies these tests that if power brakes for street cars are to be made more effective, some means must be devised for varying the brake shoe pressure during the stop. In other words, the brake shoes must be applied at the outset with a force even greater than the weight on the wheels, and this force must be reduced as the car speed slackens to prevent sliding the wheels.

This is exactly what an experienced motorman does with the hand brake, and in this respect, therefore, the power street car brake is as yet inferior to the hand brake.

As evidence on this point, it is of interest to note that a series of tests was made with a car equipped with the ordinary hand brake with spindle and chain operated by an ordinary brake handle with 14-in. sweep. Stops were made with this in distances of 35 ft. to 49 ft. from speeds of 8 miles per hour, 60 to 64 ft. from speeds of 12 miles per hour, 73 to 77 ft. from 15 miles per hour, and 86 to 89 ft. from 16 miles per hour. The wheels were not skidded at all.

Examination of Table I. will show that these results are equal to the best records made by the power brakes. We are inclined to suspect that some part of this very good record for the hand brake may have been due to the brake shoes being better worn to the wheels than was the case with the power brakes; yet even if this were the case, the record made by the hand brake is one which makers of power brakes will do well to study.

It ought to be feasible so to design a power brake as to make its action adjustable with the varying friction on the wheels, either automatically, or directly by the action of the motorman; and these tests plainly indicate that in this direction alone can progress be made.

The advantages of power brakes over hand brakes are such that they are certain to be more and more applied, especially to the heavy cars run at high speeds, which are becoming more and more common in electric railway practice. The importance of the brake gear on cars run under the conditions obtaining in street railway service cannot be overestimated. Not a trip is run but what lives depend on the efficient and certain action of the brake gear. Everything relating to its improvement, therefore, is of great importance to the public, as well as to the railway companies; and the New York Railway Commission, by its conduct of the above-described series of tests, has rendered a great public service.

LETTERS TO THE EDITOR.

Earth-Work Cross-Sections.

Sir: The writer believes there is one gem in the column of formulas upon earth-work in your issue of July 19th. It is the quotation from Professor Johnson. The subject is a very simple one. It is well understood by whoever assumes responsible charge of a little cross-section party, by his rodman, and usually by some of the other assistants. A feeble effort of the imagination insures all the hints that are necessary. The work is carried on to establish the position of three plane surfaces—namely, the roadbed of known width, and two slopes of known inclination. The proposed or imagined roadbed may be many feet beneath the ground, or far above the engineer's head, but he knows its position and the relation of the side slopes to the surface of the earth, at all times and within very narrow limits. This knowledge is continually verified or checked up as the work proceeds. The exact mental effort or conception can be more easily experienced than described. The lateral inclination of the surface should not first receive attention. Suppose a large tent having the exact cross-section of a fill to be pitched in front of some irregular ground. It would furnish a good "hint" as to where its own sides, if the tent were to be lengthened, would touch the surface of the earth. Take away the tent, leaving the tent-pins, and the difficulty, if there were any, would not be greatly increased. Take away the tent pins, and with only center elevations the engineer immediately pitches an imaginary tent and all pitch into the work. In cuts, of course, the tent is upside down, but its relation to the surface is clearly apprehended and no delay is occasioned. The simple fact is that such work is done without much conscious effort and with surprising

rapidity, around curves, in rough districts, anywhere that men can walk or scramble about. The level should be turned over to the most ambitious assistant, the engineer should use nothing but his note-book and pencil, keeping the notes from bottom to top of page; direct where readings should be taken; make all trial calculations mentally, and note down nothing but the stations and figures that define the cross-sections. He is aided by some species of intuition that can be relied upon. He knows what is to be. He sees that the slope will begin just there. It is tried, verified or corrected, measured out, an intermediate elevation noted for more accurate computation of quantities, all in less time than is required to read about it. This is the method that should be practiced and taught.

And after a few days some one in the party, if it contains any of the material of which Correspondence Scholars (who should everywhere be encouraged) and engineers are made, will volunteer to do all this and the one previously in charge can look out a better location, wrestle with a bridge formula or discover new sources of business for the proposed road. At all events, he will not be apt to think more seriously about a cross-section formula than about a pendulum formula while a swinging galt is enabling him to catch a train.

Very truly yours, M. Am. Soc. C. E.

Wabash, Ind., July 24, 1900.

Formulas for Calculating the Weights of Steel Bridges and Trestles.

Sir: Following up my tables for the weight of trusses and girders, in your issues of May 30 and June 21, I send you herewith formulas for the approximate weights of steel bridges and trestles. The unit stresses in all cases are 10,000 lbs. and 12,000 lbs. per sq. in., and the various loadings are given with the formulas. For other units and loads, the weights may be found by interpolation. These formulas have all been determined by the writer from a large number of actual cases. They will be found very useful in making approximate estimates.

Railway Bridges.—All weights are per lineal foot of single track bridge for steel only; units 10,000 and 12,000 lbs. per sq. in. The live loads assumed are two engines weighing 100 tons each, and 4,000 lbs. per lin. ft. of track:

Deck plate girder bridge	100 + 9 L
Deck lattice girder bridge	100 + 8 L
Half through plate girder bridge with floor	300 + 12 L
Same with ties on shelf angle	200 + 8½L
Same with trough floor	600 + 10 L
Riveted through truss bridge	400 + 6 L
Riveted deck truss bridge, ties on top chord	200 + 7 L
Pin through truss bridge	400 + 5½L
Pin deck truss bridge with stringers	400 + 6 L
Pin deck truss bridge, ties on top chord	300 + 6 L

Railway Trestles.—Assumed loads same as above; weight of spans as above. Weight of bents and bracing is 9 lbs. per sq. ft. of side profile from ground to base of rail.

Electric Railway Bridges.—Live load assumed 25 ton cars, or 2,000 lbs. per lin. ft. of track:

Beam bridges	30 + 5½L
Deck plate girder bridges	30 + 5 L
Pony truss bridges	200 + 1.8L
Through truss bridges	200 + 1.6L

Electric Railway Trestles.—Weight of spans as above; weight of bents and bracing is 6 lbs. per sq. ft. of side profile from ground to base of rail.

Highway Bridges with Wooden Floors.—Assumed dead weight of floor is 40 lbs. per sq. ft.; assumed live load is 100 lbs. per sq. ft.; units 10,000 and 12,000 lbs. per sq. in. The weights are per square foot of floor, and include that only with joists.

Girder bridges with sidewalks	$3 + \frac{L}{4.4}$
Girder bridges without sidewalks	$3 + \frac{L}{3.4}$
Truss bridges with sidewalks	$3 + \frac{L}{8}$
Truss bridges without sidewalks	$5 + \frac{L}{7}$

Highway Bridges with Solid Floors.—Assumed dead weight of floor is 150 lbs. per sq. ft.

Deck plate girder bridges	$3 + \frac{L}{2.6}$
Half through girder bridges	$3 + \frac{L}{2.4}$
Truss bridges	$3 + \frac{L}{4}$

In all the above formulas, L is length of span c. to c. bearing.

Very truly, H. G. Tyrrell,
Assistant Engineer Boston Bridge Works.

Boston, Mass., July 23, 1900.

PRESERVATIVE TREATMENT OF TIMBER.*

By O. Chanute, M. Am. Soc. C. E.†

The statistics concerning our forest supplies, prepared for the census of 1880, unduly impressed people as to the rapid destruction of these supplies, and this was followed by a reaction in which little attention was given to the matter until the revival of business in 1899, when the price of lumber, timber and ties advanced 20 to 70%.

The great timber users are the railways, and their principal consumption is for ties. It is estimated that the railways now lay down about 100,000,000 ties annually, this alone requiring the yearly stripping or culling of over 1,000,000 acres of our best forests, upon the assumption that an average of 100 ties are taken from each acre. Appreciating these facts, some few sagacious railways began tentatively the treatment of perishable and cheap woods for ties in 1885 and 1886. They were the pioneers in recent years, for former experimental plants had been given up, and that these leaders have already accomplished good economic results for themselves is evidenced by the fact that all save one (whose works were burned) are continuing the process now. These roads were the Atchison, Topeka & Santa Fe, the Union Pacific, the Southern Pacific, and the Chicago, Rock Island & Pacific. In 1899, the Chicago, Burlington & Quincy R. R. built a tie treating plant at Edgemont, So. Dak., which has only recently begun operation with the burnettizing process. In addition to the above, there are private works at Somerville, Tex., which operate the zinc-tannin process for ties, and at Beaumont, Tex., which treat either with zinc or with creosote, as required by the customers. Creosoting is chiefly applied to timber exposed to marine worms. It is much the best process, but is too expensive to apply to ties. There are works for creosoting at Houston, Tex., at Pascagoula, La., at Norfolk, Va., at Indianapolis, Ind., at Long Island City, N. Y., at Perth Amboy, N. J., at San Francisco, Cal., and at Seattle, Wash., which work chiefly on piles and timber. As to ties, the results of the treatment have been fairly satisfactory. They are stated in detail in a paper by Mr. W. W. Curtis, M. Am. Soc. C. E.*

The writer acknowledges that the average life in the track of ties treated at his own works prior to 1895 has not been satisfactory to himself. He expected these ties to last 12 to 15 years, and they have averaged but 9 to 11 years. In 1896, after a great many experiments, he modified the mode of treatment by using three solutions instead of two, and he now injects 2½ times as much chloride of zinc as was done in 1886, so that he anticipates that his original expectations will be realized. He has found, however, a great many anomalies in the injection of various woods. Some of the ties take two or three times as much solution as others; various kinds of wood behave differently; ties cut in summer average far less absorption than those winter cut; modifications in the period of steaming, in the time and amount of vacuum, as well as in the strength of the solution, and the duration of the pressure, produce different results, some of which were puzzling; so that after 14 years of experience, the writer felt the need of going to Europe, in order to study "the state of the art."

Practically all ties laid in England are creosoted with varying quantities of tar-oil, but generally with 28 to 30 lbs. per tie. The ties are of imported Baltic redwood, procured in Russia, Sweden and Norway, are generally 8 ft. 11 ins. long, 5 ins. thick and 10 ins. face, and cost from 90 cts. to $1.12 apiece delivered at the dock, so that it is good economy to treat them with creosote to lengthen their life.

In France, chloride of zinc and sulphate of copper were formerly injected, but now practically all the ties are creosoted (except by one road) and they last from 15 to 20 years. The Eastern Ry. obtains 25 to 30 years' service out of beech ties, and there is no question as to the fact, for accurate records for 27 years prove it, but then this road injects 60 lbs. of tar-oil per tie, after long seasoning and further drying in ovens, at a total cost of 64 cts. each. Other roads inject lesser quantities and obtain inferior results. The increased life of the wood seems to be nearly in direct ratio to the amounts of creosote injected. The French ties are of oak, beech and pine, about three-quarters of them being produced in the country, and about one-quarter imported. The average renewal upon the French railways is now about 4½% annually of all the ties in the tracks, so that the yearly depreciation in the United States is about 2½ times as much as in France.

In Germany three processes have been in vogue until recently. These consisted, first, in straight burnettizing, or the injection of chloride of zinc alone, such as is now practiced at some of the works in the United States; second, in the "zinc-creosote" process in which both substances are simultaneously injected in an emulsion; and, third, in straight creosoting, in which tar-oil alone is injected by one of several methods. In 1897 straight burnettizing was abandoned, it having been abundantly recognized that the chloride of zinc leached out of the wood in time, and at present only the other two processes remain in practical application upon an extended scale.

The reason why burnettizing continued so much longer in Germany than in England or in France appears to be mainly climatic. Not only is the rainfall less in Germany, but its character is different, consisting, as the writer was informed, mainly of long drizzling rains which do not wash the ground and the ties like the heavy downpours in the other countries, which are so often followed by fierce evaporating suns. Be this as it may, the service hitherto obtained from burnettized ties in Germany has been from 9 to 12 years in the track; the timber injected has chiefly been pine and beech, and the cost of injection for first-class ties, 8 ft. 10 ins. long, 10.2 ins. wide and 6.3 ins. thick, has been 15.6 cts. each for pine and 18.8 cts. for beech, which latter wood absorbs more solution. These woods are obtained locally, as the state owns some 31% of the forest area of Germany, makes this a source of profit, and discourages importation.

The price paid for the injection with "zinc-creosote" of first-class ties is 19.2 cts. for pine, 20.4 cts. for beech, and 15.6 cts. each for oak, inasmuch as this last wood is very refractory and absorbs much less of the solution. The service obtained has been from 12 to 18 years in the track, but the most convincing evidence of the value of the process consists in the guarantee which the contractor, Mr. Julius Rutgers (who first introduced this method), has given in some cases. He first excludes 5% of all the ties treated, as damaged by hidden defects and rotten spots which cannot be detected in inspection, and guarantees that of the remainder 95% shall still be fit for service in 10 years, 80% in 11 years, and 70% in 12 years. If less than the above remain, and are proved to have been properly taken out for decay, he makes the deficit good by refunding the price paid for treatment or treating another tie gratis, at his option. In point of fact, inasmuch as a premium of 2.4 cts. a tie is charged for this guarantee, the Prussian State Railways prefer to pay the regular price above mentioned for treatment, and to protect themselves by the issue of elaborate specifications which have been revised several times, making them more and more stringent, and by placing inspectors at the works.

In Germany, as elsewhere, straight creosoting gives the best results, but it is expensive. The price paid for the impregnation of first-class ties is 53.76 cts. each for pine, 56.64 cts. for beech and 26.88 cts. for oak, the latter being in consequence of the smaller absorption, if the creosoting is done after drying in special ovens. The price is 56.64 cts. each for pine, 59.28 cts. for beech, and 28.80 cts. for oak, if boiled and impregnated in heated tar-oil. The service obtained is 20 to 23 years for pine, 30 to 34 years for beech, and 24 to 28 years for oak; these figures as to life being taken from the report of the Union of German Railways for 1896, published in organ of railroad progress, Wiesbaden, 1897. The results must seem astonishing to our American railway managers, but then, very great care is taken of the ties after they get into the track, the mode of fastening to the rail is superior to our own, and all the inspections are rigid.

Nothing impressed the writer more forcibly than the extreme care, and the particular precautions enforced, in Europe in order to do the best kind of work. The ties are minutely inspected when first received, and the German specifications would appall an American tie contractor. If there are incipient cracks at the ends, sharpened straps of heavy tapering hoop iron, bent into the shape of an S, are driven in, or a hole is bored with an auger, and an iron bolt is inserted and screwed up against washers. The ties are then seasoned from 6 to 12 months before they are impregnated. They are cribbed up in isolated square piles of about 100 ties, with 4 ins. air spaces between the sticks, so that they may dry thoroughly in the yards adjacent to the treating works.

The work of impregnation is subjected to the greatest care. It is carried on by experts, and to elaborate specifications. As most applicable to the United States the specifications of 1895 of the Royal Prussian State Railways are herewith given in an appendix. While carrying on the work, inspectors are in attendance to test the strength and purity of the substances injected, and for this purpose a chemical laboratory is attached to each treating plant; the ties are weighed by buggy loads before and after treatment, and the amounts absorbed are thus checked. If a buggy load proves deficient it is treated over again. To ensure uniform work, automatic gages with clockwork attachments register the amounts of vacuum and pressure obtained in the treating cylinder, as well as their duration, and a record diagram is taken and preserved of each treatment. Thus is obtained a uniform absorption of the chemicals in the prescribed quantities and thus are produced the satisfactory results in service which have already been mentioned. Much of the credit for the careful work done in Germany is due to Mr. Julius Rutgers, a contractor who has been in the business for just 50 years, and now controls some 20 plants which do most of the tie treating for Germany.

Further care is exercised in laying the ties in the track, and the mode of fastening to the rail is decidedly superior to our own. In France and in Germany, the tee-rail is generally used, together with tie-plates, and the latter are fastened to the tie by lag screws of various designs. In some cases spikes are used on the outside, but the lag screw, or screw spike, is considered the standard. In France, holes for these are bored by machinery, but the Germans now generally bore these by hand when laying in the track. They admit that it would be cheaper and better to bore before treatment, so as to impregnate thoroughly around the hole, but they are now experimenting with so many patterns of tie-plates and rails that they cannot tell before treatment to which pattern the

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tie is to be fitted. The French have been using not only iron tie-plates, but also some made of felt, and claim that the latter last 6 to 10 years, at a cost of 1.6 cts. each, but these are now being superseded by creosoted poplar tie-plates, cut from the lower gnarly portion of the tree, to about the thickness of a shingle, which are said to be more economical than either iron or felt tie-plates. The argument made is that the iron tie-plate wears both the rail and the tie, while the poplar tie-plate takes all the wear to itself, and, as it costs but about 0.8 ct., proves most economical. The sooner we set about to supersede our common spike with some form of lag screw appropriate to our rails, the better it will be for track economy.

Some modifications of burnettizing may profitably be employed in this country. Indeed, in the more arid regions of the United States chloride of zinc alone will probably give satisfactory results, but there must be plenty of it injected, certainly more than is the practice at present at some of the works; for it has been well established that it leaches out during the alternate soaking and drying which the ties undergo.

It will be observed in the German specifications hereto appended, that a pine tie, for instance, which contains 3.96 cu. ft., is required to absorb 35 kilograms, or 77 lbs. of the solution; as this solution is specified to be at 3.5° Beaume, which contains 2.63% of dry zinc-chloride, it follows that the amount of the latter substance carried in by the aqueous solution is 1.92 lbs. per tie, or at the rate of 0.49 lbs. per cu. ft. This corresponds to the present practice of the writer, who has been injecting, as closely as possible, 0.50 lb. per cu. ft. for the last three or four years, with what practical results we shall not know to an absolute certainty for 8 or 10 years to come. As the ties reach him much worse seasoned than is the practice in Germany, and as he cannot inject as many pounds of solution, he is making the latter 5° Beaume strong, containing 3.9% of zinc-chloride, and he thus puts in as much dry chloride as the Germans. This refers to the first solution employed, which is followed by two others. The second consists of gelatine or glue, and the third of tannin, the peculiarity being that these two latter substances, which are both soluble, form, when brought into contact with each other, an insoluble compound, an artificial leather in fact, the pellicles of which lodge in the sap cells of the wood and obstruct the ingress and egress of moisture, but not of vapor. The wood being already nearly filled by the first solution, the last two do not pentrate very far, say about ¾-in., but this is sufficient to act as a rough plug, and it has been proved to retard materially the leaching out of the zinc. It has, moreover, been found important to allow the ties so treated to dry somewhat before being put into the track, in order to allow the pellicles of artificial leather to harden. It has also been found that the ties last better in some soils than in others; limestone ballast and coal mine refuse, or culm, being seemingly the most injurious. For regions of considerable rainfall, the writer entertains no doubt that this "zinc-tannin" process is superior to straight burnettizing when equal amounts are injected.

The German method of retarding the leaching out of the chloride of zinc (for they say that it washes out even then), has been to mix therewith a certain quantity of tar-oil, which, by lining the sap cells of the wood and hardening therein shall prevent the intrusion and the exit of moisture. The success seemed, by report, to be so much greater than that with ties treated by the "zinc-tannin" process, from 1886 to 1896, at the works of the writer, that he devoted great scrutiny while abroad to the "zinc-creosote" process, with a view to adopting it should it clearly be superior. As a result of that scrutiny he believes it to be very good, but he is not now certain that the results will warrant the increased expense, which will be 3 or 4 cts. a tie, inasmuch as a part of the increased service in Germany, as compared with the United States, is attributable to other causes, such as the more thorough seasoning of the wood, the better track fastenings, the character of the rainfalls, etc. It is a significant fact that the Germans report a life for untreated white oak of 10 to 16 years, with an average of 13.6 years, while we can only obtain a life of 8 to 10 years for that wood in this country. Moreover, it will be noticed in the specifications appended, that while for straight creosoting only 10% of tar-acids are required in the tar-oil, for the "zinc-creosote" process a peculiar quality of tar-oil, containing 20 to 25% of tar-acids is required, which quality is not now produced in the United States. The introduction of this process therefore requires material changes in the distillation of coal tar in this country, or the importation of foreign tar-oils, which are just now very scarce and high.

Be this as it may, the writer deems it desirable that the "zinc-creosote" process shall be introduced in the United States, and it is his intention to do so, but it will require some time to investigate the best sources of supply, and to make chemical analyses of the products, and it will perhaps be necessary to erect a tar-oil refinery, as the process has to be carried on with great nicety, and some of the foreign plants are found to do much better work than others.

The question also occurs whether there are not other cheap processes which might be profitably introduced in this country. The writer learned of three new methods now being promoted in Europe. One is the "Hasselmann" process, which consists in boiling the wood in a solution of the sulphates of copper and iron, with alumina and "kainit," a salt mined at Stassfurt, Germany, consisting chiefly of sulphate of potassa and magnesia, and the chloride of magnesia. The process has been experimented with about three years in various parts of Germany, but of course the time is too short to be sure as to the results. Another process, now being experimented upon by a Berlin chemist, may be termed the "water-creosote" process. It consists in mixing intimately tar-oil with water in varying proportions; the rationale of which is that the tar-oil will be thereby much more uniformly distributed throughout the wood, and hence a less quantity will suffice. The writer saw a number of specimens prepared by this process in Berlin, and they seemed to be quite uniformly impregnated. Still another process is being worked up in Russia, where some skillful chemists say that they have obtained an antiseptic element from the refinement of petroleum, and are studying its practical application to the preservation of timber. The weak point, however, about all new processes, is that they require the sanction of time before it is safe to adopt them otherwise than experimentally. Chemists have so many times been disappointed by the results obtained with antiseptics or methods which they recommended that it is now recognized that a process should be tested 10 to 15 years in track before it is adopted fully. It seems to be well established that any soluble salt will wash out of the wood in time, and theoretically it would seem most desirable to replace the water used in making the solutions with an oily solvent to carry in the antiseptic and thereafter resist the intrusion of moisture. The writer has been seeking such a solvent for 15 years; he has made experiments himself and has had them made by chemists, without ever having been able to obtain a true solution of an antiseptic in an oily medium. He would have great faith in such a combination as a preservative of timber.

There are now signs that the preservative treatment of timber is destined to be considerably extended in this country, and it is hoped that this paper will conduce to the promotion of good work and to economical success.

Appendix.

Royal Prussian State Railway Administration.—Specifications for Treating Ties with Chloride of Zinc and Tar Oil (Julius Rutgers System).

The timber in the hermetically-closed impregnating cylinder is first subjected to the action of steam. The time necessary for steaming depends on the time of the year, and the condition of the wood. The object of this steaming is to put the timber in a condition for absorbing the greatest possible amount of the preserving fluid, to dissolve and to remove the mixture of sap, sand and dirt at the faces of the ties, and which is likely to cover the ends. The admission of steam to the cylinder is to be so arranged that the gage attached to the cylinder shall indicate a steam pressure of 22 lbs. at the end of not less than 30 minutes after beginning the process. This steam pressure must be kept up for a further period of 30 minutes. For green timber, the steam pressure must be kept up for 60 minutes, as otherwise it probably would not absorb the amount of impregnating fluid specified in the contract. In order to expel the air from the cylinder at the beginning of the steaming, a valve attached to the lower part of the cylinder must be opened until steam begins to escape; this valve must also be opened from time to time during the process of steaming, in order to draw off the water of condensation.

The above rules apply to oak and pine timbers. As beech wood contains larger amounts of sap, which easily ferments, steaming must be continued at the above-mentioned pressure for such time that the sap in the heart of the tie shall reach the boiling point. In treating beech wood, whether it be green or seasoned, steaming shall be continued for four hours at the above-mentioned pressure, including the 30 minutes which are required to produce the pressure of 1½ atmospheres. After steaming the wood for a sufficient length of time the steam is allowed to escape from the cylinder.

After the steam is exhausted from the cylinder a vacuum of 23.6 ins. of mercury, as indicated on the gage, is produced in the cylinder, and this must be kept up for 10 minutes. Thereupon, without decreasing the vacuum, the process of filling the cylinder with the chloride of zinc solution, previously heated to at least 65° Celsius (149° F.) is begun. While the chloride of zinc solution is being heated, an amount of 2 Kg. of tar oil shall be added to the solution for each tie of a length of 2.50 m. and over, or 20 Kg. tar oil for each cubic meter of timber. The mixing of the tar oil with chloride of zinc solution shall be done by means of an efficient mechanical device, and a jet of steam and air.

After filling the cylinder, the chloride of zinc solution is forced into the timber by means of a pump, the pressure being raised to at least 103 lbs. per. sq. in. In order to saturate the timber as completely as possible, the pressure must be maintained for pine and beech wood for at least 30 minutes, and for oak 60 minutes. If necessary, the time must be extended until the specified amount of solution has been absorbed. This process completes the impregnation, and the solution is then drawn off.

The solution of chloride of zinc used for impregnation must be as free as possible from impurities, particularly from uncombined acid. The solution must have a strength (density) of 3.5° Beaume = specific gravity of 1.02[illegible] at a temperature of 15° C. (50° F.) A solution of [illegible] strength contains 1.26% of metallic zinc.

The tar oil must contain not more than 1% of oils that boil below 125° C. (257° F.). The boiling point of the tar oil as a whole must lie between 150° and 400° C. (302 and 752° F.) and not more than 25% must be more volatile below 235° Celsius (455° F.). At least 20 to [illegible]% of its constituents must be acids dissolving in caustic soda lye of 1.15 spec. grav. (oils of the creosote or carbolic acid type). At 15° Celsius (59° F.) the tar oil must be completely fluid, and must be as free as possible from naphthaline, so that when distilled in glass vessels in groups of 50° each (fractional distillation) it shall give off not more than 5% of naphthaline. The specific gravity of the tar oil at 15° celsius (59° F.) must lie between 1.[illegible] and 1.055.

It is guaranteed that the average amount of solution absorbed in each cylinder charge will be as follows:

a. For a pine tie 16 × 26 cm. and 2.7 m. long.....35 Kg.
   For a beech tie of same dimensions.....36 Kg.
   For an oak tie of same dimensions.....11 Kg.
b. For a pine tie 16 × 26 cm. and 2.5 m. long.....32 Kg.
   For a beech tie of same dimensions.....34 Kg.
   For an oak tie of same dimensions.....10 Kg.
c. For a pine tie 14 × 24 cm. and 2.5 m. long.....26 Kg.
   For a beech tie of same dimensions.....27 Kg.
   For an oak tie of same dimensions.....8 Kg.
d. For timbers of various sizes per cubic meter:
   For pine of various sizes per cubic meter.....310 Kg.
   For beech of various sizes per cubic meter.....320 Kg.
   For oak of various sizes per cubic meter.....100 Kg.

This guarantee is made subject to the proviso that the timber is sound, has been felled in winter and is seasoned, so that a cubic meter of pine does not weigh over 630 Kg., a cubic meter of beech, 725 Kg., and a cubic meter of oak, 800 Kg.

If the guaranteed absorption cannot be attained on account of insufficient seasoning or exceptional density of the timber, the solution must be strengthened. For instance: If a cubic meter of pine absorbs but 200 Kg. instead of 310 Kg. of chloride of zinc solution, the density of the solution must be increased to 5.43° Beaume, so that the solution used for impregnation, reduced to its contents of pure, dry chloride of zinc, shall be equivalent to the guaranteed absorption.

The samples used in testing the solution must be taken from a tube communicating directly with the impregnating cylinder. In case a test shows that the solution requires strengthening by the addition of a more concentrated chloride of zinc solution, a second test shall be made after the strengthening, in order to make sure that a solution of the specified strength has actually been present in the impregnating cylinder for a period of 30 minutes.

In order to determine the amount of solution absorbed in the process of impregnation as described, the timber is to be weighed twice on platform scales, first before being introduced into the cylinder and again immediately after treatment, while being taken out of the cylinder. The difference in weight shows the quantity of preserving fluid absorbed.

HYDRAULIC SHOCK IN WATER PIPES AND ITS REMEDY

At the initiative of Mr. Nicholas P. Simin, Chief Engineer of the Water Works, Moscow, Russia, experiments were undertaken in 1897 and 1898 to investigate the subject of hydraulic shock or water hammer. The work was done at the Moscow water-works under the direction of Mr. N. Joukowsky, Professor at the Imperial University at Moscow, who has analyzed the results of the experiments in a paper read before the Russian Technical Society. This paper has been translated into German under the title "Ueber den Hydraulischen Stoss in Wasserleitungsrœhren." and published by the Commissioners of the Imperial Academy of Sciences at St. Petersburg.

The experiments were quite extensive and have been ably handled by Mr. Joukowsky, who has also reviewed the work of previous experimenters in Europe and in America. In view of the great importance of this subject to the engineers of water works and hydraulic power plants, we have translated the following summary of results from the original paper, to which we refer those who desire further information:

(1) Hydraulic shock is propagated along water-pipes with a constant velocity, the magnitude of which, as far as observed, does not depend on the force of the shock. This velocity depends upon the material of the pipe and upon the ratio of the thickness of its walls to the diameter of the pipe. As, in the usual cast-iron pipes, the above ratio diminishes slightly with increase in dimensions of the pipe, the velocity of propagation of the shock wave is somewhat smaller in large pipes than in pipes of medium diameter. For pipes of medium diameter, 2 to 6 ins., this

velocity is about 4,200 ft. per sec., and for large pipes, 24 ins., about 3,200 ft. per sec. The velocity of the wave is the same whether the shock arises from the stopping of the water in the pipe or from a very sudden increase of pressure at the beginning of the pipe.

(2) Hydraulic shock is propagated in the pipe with uniform force. Its magnitude is proportional to the velocity of the stream lost by the shock and to the velocity of propagation of the wave in the pipe. With the usual cast-iron pipes of medium diameter, we have for each foot per second of velocity lost a pressure due to shock of about four atmospheres, and, for large pipes, of about three atmospheres.

(3) The appearance of periodic oscillations in pressure in water-pipes is completely explained by the reflection of the shock wave at the ends of the pipe.

(4) The motion of the water as a body has no noticeable influence upon the shock, and the latter is determined only by the lost velocity. When the shock wave passes through a pipe from which water is streaming, the wave is reflected from the beginning of the stream the same as from a reservoir with constant pressure.

(5) A dangerous increase of the pressure due to shock arises in the passage of the wave from pipes of large diameters to pipes of smaller diameters. In this way the pressure of the shock may be doubled when it reaches the closed end of the pipe. This doubling may be repeated a few times, so that, under unfavorable conditions the pressure may grow to large dimensions.

(6) The simplest means to protect water-pipes from hydraulic shock appear to be devices to secure the slow closing of valves and cocks.

The duration of the closing must be proportional to the length of the pipe. Air-chambers of proper dimensions placed near the valves and cocks destroy almost entirely hydraulic shock and do not allow the shock waves to pass through them when they are placed upon the line of the pipe, but the conservation of the air in the chambers is very difficult. Safety-valves placed upon the line of pipe allow to pass by them only a shock corresponding to the elasticity of the spring.

(7) From the shock diagram from a given pipe the location and size of bodies of air in the pipe may be determined. The shock diagram may be used to determine the position of leaks in the pipe, and moreover, can give indications of the condition of the pipe.

A TIE-PLATE SETTING AND SURFACING GAGE.

The use of steel tie-plates for railway track is now so extensive and so general that special methods and tools are being devised for fitting them accurately and properly to the tie, so as to give an even bearing on the tie and to give the correct gage of track when the rails are laid. We illustrate herewith a tool that is being introduced on several roads for this purpose. The general design and details of construction are shown in Fig. 1. The bar (A) is of 1-in. gas pipe, 3 ft. 11½ ins. long over all, with part of its length finished to a diameter of 1¼ ins., and having two graduated scales marked upon it, as shown. At one end is riveted a head (B) of malleable iron, having a flat blade 8 × 10½ ins., with a square 3-16-in. rib. At the other end of the bar is an adjustable head (C), also of malleable iron, having a blade very similar to that of the fixed head (B), but with a spur or lug (D) projecting beyond it. The socket or sleeve of this adjustable head fits over the turned end of the bar, and is split so as to form a clamp. Through the lugs on this sleeve passes a 7-16-in. screw (E), with a malleable iron thumb nut for tightening or releasing the clamp. The weight of the gage complete is about 22¼ lbs.

In using this tool for placing tie-plates on ties already in the track, the line rail is first accurately lined, and the opposite or gage rail is swung out to the ends of the ties for a few rail lengths. The tool is then placed on a tie, with the end of the fixed head (B) fitted against the web of the line rail, the head (C) being adjusted on the bar at such a position that a tie-plate set against the end of the blade and the projecting spur (D) will be in proper position for spiking the rails to gage. This is shown in Fig. 2. The plate is then set and lightly fixed by a blow from a wooden maul or beetle, the tool being then set on the next tie. The end of the fixed head is made concave as shown, so that only the corners of the head will touch the rail, thus setting the gage more effectively at right angles to the rail, if the web should be uneven, than if the whole edge had a bearing. As many spikes are withdrawn, and as much adzing is done as possible before the rails are moved. Then when the traffic permits, the rest of the spikes are withdrawn, the rails are thrown out, spike holes plugged, and seats adzed and leveled. The men work in gangs of three, one to set the gage and place the tie-plate in position, the other two having wooden mauls weighing 16 or 18¾ lbs., with ordinary spike maul handles about 36 to 38 ins. long, to drive the plate down so that its flanges or claws will have a firm hold in the wood. When a sufficient number of plates have been thus set, one of the gangs can be sent back to throw in the rails and spike them, the spike holes in the plates giving the proper gage. The inventor considers that a maul lighter than 16 lbs. may be used, if its face is large enough to cover the tie-plate, but some men prefer an even heavier maul. If the plates have longitudinal flanges, the first blow at least should be struck from a position at right angles to the flanges.

Considerable economy in track work may be ensured by placing the plates on new ties for renewals before the ties are put in the track. This can be done by the section men in bad weather or during the winter. In using the tool for this purpose, the adjustable head (C) is clamped in such a position on the bar that tie-plates of the size to be used will be in position for the proper gage of track when they are set with their ends butting against the faces (F) (G) of the tool, as in the elevation, Fig. 3. When set in this way the flat blades of the two heads will fit on the seats for the tie-plates. The tool is then set on the tie to test the surface of the seats, and these are then adzed or dressed as required to give an even and level bearing. The tool is then turned over and set with the faces (F) and (G) resting on the tie as shown in the plan, Fig. 3, and one plate is put in position, being gaged and squared by fitting against the face (F) and the blade (B). This plate is then set by means of the wooden mauls, when the tool is put back in the same position, fitting against the plate, and the second tie-plate is then placed and set in the same way. The tool is frequently used for testing the level and surface of the rail seats of the ties when tie-plates are not to be used.

The several operations are effected easily and rapidly, and the men very soon become expert in the use of the tool. The following table shows the record of actual time consumed in setting and embedding the Q. & C. steel tie-plates by section gang No. 20, on the Buffalo Division of the Buffalo, Rochester & Pittsburg Ry. This was their first work with the tool, and the time given includes the opening and closing of the track for trains. Mr. Julius Spangler was the foreman in charge. The men were paid $1.25 per day.

The tie-plate gage is the invention of Mr. Henry Ware, Roadmaster of the Buffalo, Rochester & Pittsburg Ry., and is already in quite extensive use on some important railways. It is being manufactured and introduced by the Buda Foundry & Mfg. Co., of Harvey, Ill., and we are indebted to both the inventor and the manufacturers for the particulars of the tool and its use.

Mr. Ware has daily reports made by the section foremen showing the work done in placing tie-

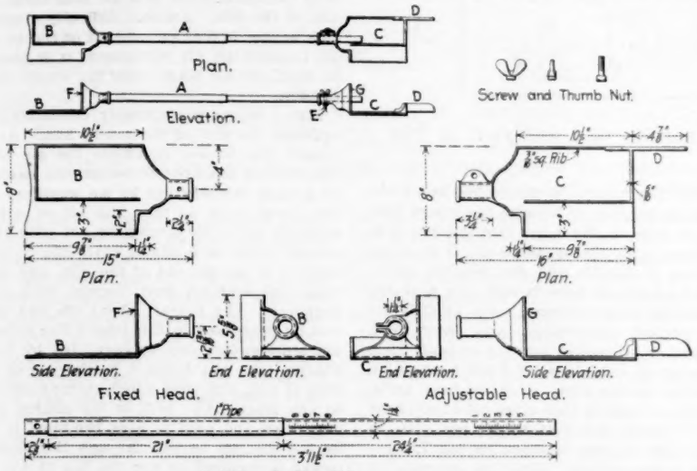


FIG. 1.—GAGE FOR SETTING TIE-PLATES.

Henry Ware, Roadmaster, B., R. & P. Ry., Inventor; Buda Foundry & Mfg. Co., Maker.

Table Showing Actual Time Consumed in Setting and Embedding Tie-Plates; Buffalo, Rochester & Pittsburg Ry.

Date.	Track open, hrs.	mins.	No. of Men—With gages.	No. of Men—With beetles.	Plates put in.	Cost.	Cost per plate.
Aug. 24	1	20	1	2	192	$0.97	$0.0025
	1	15	1	2	192		
	2	35	..	..	384		
Aug. 25		20	1	2	75	1.125	.0018
		18	1	2	65		
		30	1	2	84		
		25	1	2	76		
		45	1	2	149		
		15	1	2	54		
		15	1	2	57		
		15	1	2	49		
	3	03	..	..	608		
Aug. 26		45	1	2	156	1.06¼	.00175
		50	1	2	163		
		55	1	2	188		
		20	1	2	88		
	2	50	..	..	595		
Aug. 27		35	1	3	246	.87	.00109
		35	1	3	201		
		40	1	3	259		
	1	50	..	..	706		
Aug. 29		18	1	2	89	.39	.0015
		45	1	2	170		
	1	03	..	..	259		
Aug. 30		35	1	3	212	1.11	.0015
		18	1	3	118		
		18	1	2	67		
		40	1	2	183		
		15	1	2	54		
		25	1	2	98		
		15	1	2	49		
	2	46	..	..	736		
Aug. 31		40	1	3	205	.65	.0015
		40	1	2	201		
	1	20	..	..	406		

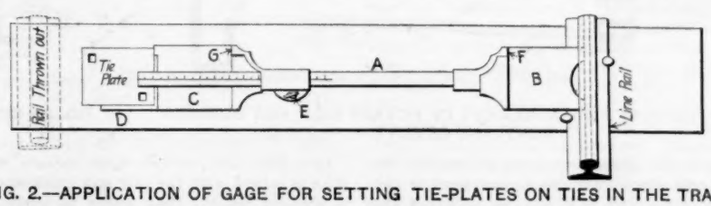


FIG. 2.—APPLICATION OF GAGE FOR SETTING TIE-PLATES ON TIES IN THE TRACK.

plates. This report is in tabular form, with the following headings: (1) Curve number (all the curves are numbered for convenience); (2) time of opening track; (3) time of closing track; (4) reason for closing track; (5) number of tie-plate gages used; (6) number of mauls or beetles used; (7) number of men in gang, including flagmen; (8) kind of ties; (9) number of tie-plates embedded; (10) trains held.

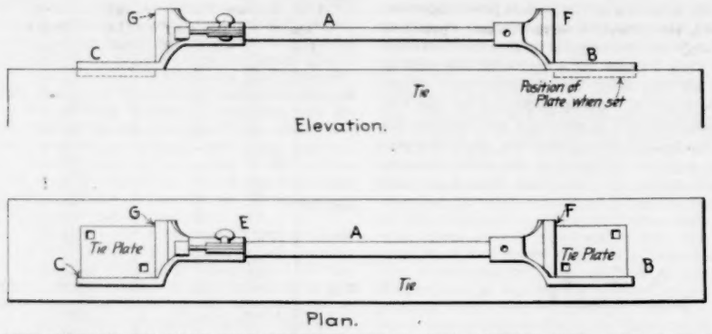


FIG. 3.—APPLICATION OF GAGE FOR SETTING TIE-PLATES BEFORE TIES ARE PUT IN THE TRACK.

COMBUSTION IN PORTLAND CEMENT KILNS.

By Edward Duryee.*

The rapid development of the Portland cement industry in this country, where extensive plants involving large amounts of capital are going up at most widely-separated geographical points, indicates a prosperous and healthy condition of the cement business. This growth is a natural consequence of several favoring circumstances. In engineering construction the age of steel and cement has come, and with it the market for cement is growing by enormous strides. The output of the American Portland cement mills last year was 6,000,000 barrels, as against 4,000,000 barrels the year before. Another important circumstance lies in the improvements made in the rotary kiln process due to American inventive talent, which have enabled us to sell American Portland cements equal in quality to the foreign brands at much lower prices than can be reached by the imported cements. The utilization of natural gas in some locations, of cheap ground coal, and of fuel oils, in others, are throwing the practical as well as the theoretical advantages in the matter of fuel on the side of the rotary as against the other kiln processes. The latest construction of rotary kilns make them from 60 ft to 75 ft. long, and arranges the setting at the lower end so as to prevent the ingress of cold air. Another improvement is the plan of preparing the raw mix by reducing the original raw materials to an impalpable powder in as near their native condition as possible, and after standardizing this mixture, feeding it directly into the kiln to be burned. All these and other improvements contribute to economy in production of the cement. These conditions have alarmed foreign producers, and during the last year several representatives of leading foreign manufacturers have been in this country seeking desirable locations for cement mills with a view to establishing cement plants here for making cement by our American rotary kiln processes.

The rotary kiln process as it is usually conducted, however, is susceptible of many important improvements, and it is the object of this article to call attention to a form of rotary kiln which the writer has used for burning cement since 1891, and which he believes has many advantages over those in common use.

*Chemist for California Portland Cement Co., Colton, Cal.

Combustion in Rotary versus Dome Kilns.—With oil and coal at fair prices, the theoretical and practical advantage appears to be with the rotary kiln. In the use of coke in the dome kiln there is considerable expense in coking the coal; it is bulky and expensive to handle and the heating power of the volatile hydrocarbons is lost. In a rotary kiln the gaseous hydrocarbons, such as CH_4 are burned to perfect combustion, and their heat, which is great, is utilized in burning cement. Thus carbon burning to CO gives off 2,400 heat units, carbon burning to CO_2 gives off 8,000 heat units, and hydrogen burning to H_2O gives off 34,000 heat units. The calorific power of Marsh gas, CH_4, is 14,675, while that of coal is given as but 7,865.

The writer is aware that, "While the quantity of heat generated by the combustion of hydrogen is much greater than in the combustion of carbon, the product of combustion through which the heat is diffused is nearly two and one-half times as great as in that of an equal weight of carbon. A portion of the heat generated in the combustion of hydrogen, too, becomes latent and ineffective for increasing the temperature, being consumed in determining the vaporous condition of the water vapor produced."* Still an enormous advantage is on the side of a kiln that utilizes the heat of the hydrocarbons in coal or oil and does it in such a way that the initial heat of the gas and of combustion is thrown into the kiln. The ideal arrangement is to have a gas producer opposite and near the end of the rotary as shown by Fig. 1.

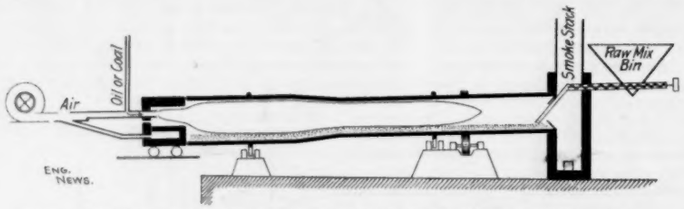


FIG. 1.—IMPROVED ARRANGEMENT OF ROTARY KILN FOR BURNING PORTLAND CEMENT.

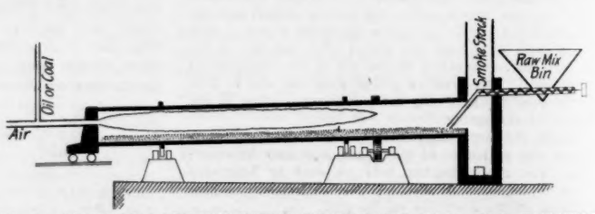


FIG. 2.—ORDINARY ARRANGEMENT OF ROTARY KILN FOR BURNING PORTLAND CEMENT.

In a dome kiln, as in a blast furnace, where the coke is mixed with the raw mix brick or ore, there is another feature that works to lower the temperature. It is necessary to maintain a supply of oxygen and a constant draft to remove the products of combustion; there is a tendency for the products of combustion and air to become mixed and thereby diminish the efficiency of the air and fuel in supporting combustion, and thus maintaining the necessary high temperature.

There is a marked contrast to these conditions in a rotary kiln, in which the gases are not impeded by superimposed brick and fuel, but have free exit from the combustion chamber, through the kiln to the smokestack, save that the quantities of fuel, air and raw mix are under constant control of the person in charge by means of valves regulating the supply of each.

*Watts' "Dictionary of Chemistry," p. 725.

Combustion at High Temperatures.—The highest temperatures facilitate the union of carbon and hydrogen with oxygen. Whether carbon dioxide or carbon monoxide is produced at high temperatures depends, within rational limits, upon the proportion of carbon and oxygen present in spaces capable of uniting. Reference to Fig. 2 shows the common method of burning oil or coal dust in rotary kilns. In this kiln the fuel is sprayed by a jet of air from an air compressor, under a pressure of about 15 lbs., directly into the kiln. It thus comes into contact with the raw mix at once and the latter exercises the tendency before explained to lower the heat and make both the burning point of the fuel and the clinker variable and imperfect, or if not so, more fuel is required to overcome this difficulty. This arrangement of the burner also acts like an injector to draw cold air in about the end of the kiln. Another difficulty connected with this burner is that on account of the air having to go through an air compressor it is impracticable to heat the air blast with the waste heat of the clinker.

Fig. 1 shows a stationary combustion chamber opposite the end of the rotary kiln. An ordinary rotary fan blower furnishes the air blast. The combustion chamber or retort can easily be kept at a high temperature by an auxiliary burner in the lower part so that the oil or coal and air sprayed with this generator act with the utmost energy upon each other, enter the rotary in full volume to fill the end of the kiln, and maintain a high and uniform heat therein, with the utmost economy. The indraft about the end of the kiln can be prevented in this case. The point of highest temperature can be regulated by the man in charge, who can focus it further up or down the kiln at will, and thus avoid burning out the lining at one place. The heat in the clinker can be regenerated and used to heat the blast in this case, as hot air can be put through the blower. Less power is required to run the fan blower than the compressor used in the Fig. 2 kiln.

There has been but little written about the character of the heat required in burning Portland cement. It has been claimed by those who favor the dome kiln that a reducing heat is necessary, and that this heat could not be had in a rotary kiln. Others have claimed that an oxidizing heat was the one used, while still others have thought either of these or even a neutral heat would answer. The writer has made this subject one of considerable study, both with wet and dry processes in rotary kilns, and in his experience has found that the essential point in burning Portland cement and lime is temperature. With the right temperature good cement can be burned with either a neutral, oxydizing or reducing flame. Under ordinary conditions the heat in a rotary kiln is of an oxidizing character, and this condition attends complete combustion of the fuel, no free carbon or unsatisfied hydrocarbons in the gases in the stack. The results of tests of the gases on one day were as follows:

Results of Tests of Gases in Smoke Stack of Rotary Cement Kiln.

	CO_2.	CO.	O.
Sample 1, smoke colorless.....	22%	00%	5%
Sample 2, smoke little black.....	28	00	4
Sample 3, smoke some black.....	30	00	2.0
Sample 4, smoke black.....	33	00	2.2

The percentages given in the table were by volume. The varying proportions were produced by feeding more or less oil, and by regulating the damper in the smokestack. The changes were made for experimental purposes; the normal condition is shown in the results of the test of Sample 1.

SPEED VARIATIONS OCCURRING DURING THE CYCLES OF THE OTTO GAS ENGINE AND THE DIESEL HEAT MOTOR.*

The gas engine from which the following measurements were taken was an Otto-Crossley engine, situated at the works of the Morgan Spring Works, at Barber's Crossing, Worcester, Mass. It was of the usual horizontal, single-acting, single-cylinder type, having a cylinder 18½ ins. in diameter by 24 ins. stroke, and two flywheels, each weighing about five tons. It was rated at 100 HP., at 180 revolutions per minute, and was fed with power gas from a producer of the Dowson type, manufactured by the Morgan Construction Co. At the time these tests were made, however, the governor was set to give a mean speed of about 164 revolutions, and the mean load on the engine was in the neighborhood of 60 HP.

There was considerable variation in the form of individual indicator diagrams taken at different times. The mean effective pressure varied between observed extremes of 40 and 75 lbs. per sq. in., and may have exceeded these limits at other times. In the weaker explosions, too, the maximum pressure was naturally attained much later in the stroke than in the stronger ones; and these two facts combined to make a difference in the speed variations between cycles having the stronger or the weaker impulses, which is well revealed in the curves.

Another feature peculiar to this engine, which had its effect upon the speed variations, was the fact that the engine was directly coupled to a line shaft nearly 100 ft. long, at the further end of which was a heavy pulley giving off power through a rope drive. This shaft must have possessed considerable flexibility in the way of torsion, and when the strain due to the impulse was felt it doubtless stored up considerable resilience, which worked backwards towards the engine immediately the impulse stroke was finished. In other words, whereas the application of flywheel weight to an engine in the usual manner inevitably acts to steady its motion, the effect of flywheel capacity at the other end of such a length of shaft may have the opposite effect of exaggerating the results of variation in impulse, by letting the engine run ahead through some slight crank-angle before its resistance is felt, and by afterwards pulling the engine backwards as the resilience of the shaft gradually brings the engine and the distant flywheel into synchronous rotation. How great this effect may have been in this case could not be investigated by the students, owing to lack of time; but it is certain that the chronograph revealed variations which were not only more sudden and frequent than the imagination could depict as being natural on the part of a pair of 5-ton flywheels, but which were entirely without mechanical explanation by the known sources of speed variation, viz.: variations in the fluid pressure and inertia forces at work upon the wrist pin. The chronograph was suspected of error; but though it was impossible to clear it of this suspicion with certainty, yet no distinct source of error was found. The resilience of the long shaft was, therefore, reverted to as a probable explanation.

The chronograph consisted of a drum mounted between the centers of a lathe bed, and alined with the engine shaft. On its surface was laid a sheet of smoked paper, and upon the paper were traced the vibrations of an electrically-driven tuning-fork. A second tracer recorded the opening of the gas-admission valve, or the lack of it, as the case might be. The whole apparatus was set in motion and the tracers properly adjusted, while the lathe-carriage and the forks attached to it were stationary. When all was ready the throwing-in of the lead-screw connection started the tracers across the sheet, screw-thread fashion, and when the limit of the sheet was reached the throwing-out of the lead screw removed all danger of self-destruction of the apparatus and gave full leisure for the removal of the record.

The connection to the engine was made and broken while the latter was in motion in the following way: The back gear of the lathe was removed, turned end for end, and supported in special brackets which allowed the two big gears to mesh with one another. The back-gear spindle was rigidly coupled to the engine shaft while the latter was at rest, and thereafter revolved synchronously with it and without lost motion between the two. A little crossed belt laid between the back-gear spindle and the cone pulley was ordinarily left lying loosely on the lowest step, thus permitting the main spindle to be at rest. When connection was desired this belt was shifted to one of the larger steps and to a wooden pulley on the back-gear spindle of the same diameter. This set the main spindle into motion by friction and gave to it a speed closely equal to that of the engine, but not a sufficiently certain replica of it to suffice for chronometer measurements. The throwing-in of the back gear, however, could now be done without harm and the motion of the live spindle made an exact reproduction of that of the engine shaft.

This chronometer was rigged up out of such stuff as is ordinarily to be had in any machine shop, with the exception of the large tuning-fork and the two little electro-magnets. Aside from the annoyance always attendant upon the adjustment of a tuning-fork and tracer to work properly upon smoked paper, the chronograph was found quite convenient and satisfactory.

The Diesel motor from which the measurements were taken was the 20-HP. single-cylinder vertical engine which was tested for efficiency by Prof. Denton, and which afterwards was exhibited at the Mechanics' Fair in Boston. Its cylinder measured 10.23 × 16.16 ins., and its normal speed was 180 revolutions per minute, to which it closely adhered. At the time that the tests were made its power was absorbed by an Alden dynamometer.

Referring to the curves obtained, Fig. 1 shows the Otto engine running under what might be called a friction-load, though it involved much more than the friction of the engine itself. The record covers nearly twenty complete cycles, in all but five of which the governor refused to open the admission valve. Owing to the suspicions attaching to the smaller variations in speed variation between one cycle and another, even when the conditions were quite unchanged from one cycle to the next, it was deemed safer to average the results for all of the "missed" cycles and for all of the "impulse" cycles, and then to apply this average result to each cycle alike, keeping, however, the mean speed of each particular cycle unchanged. The same process was used in producing Fig. 2, and certainly for the friction diagram the result is more satisfactory and probably more reliable than if the record coming from the chronograph were taken without alteration; the extremes of variation are reduced, which makes the result a safer one to accept, and the curve better typifies to the mind the average conditions prevailing in the engine than when all of the vagaries of speed variation are reproduced. To show what these may be, however, the record of the first five cycles of Fig. 2 is given in Fig. 3 just as it came from the chronograph. The differences between cycles 1, 2 and 3 are easily explained by the difference between the impulses obtained in one cycle and another, and the extremes of variation are probably no greater than are actually attained in the actual engine.

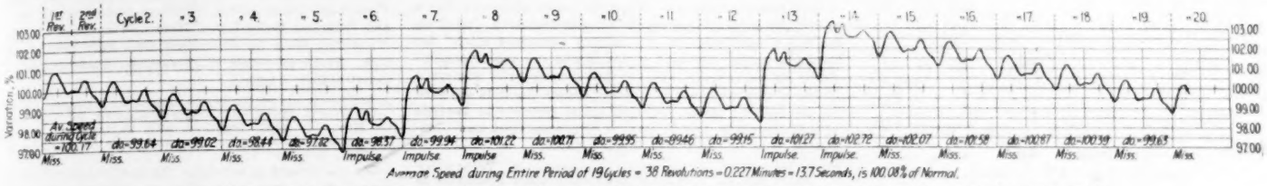

1st Rev.
2nd Rev.
Cycle 2.
Variation, %
Av. Speed during Cycle = 100.17
Average Speed during Entire Period of 19 Cycles = 38 Revolutions = 0.227 Minutes = 13.7 Seconds, is 100.08% of Normal.

FIG. 1.—DIAGRAM SHOWING SPEED VARIATIONS UNDER FRICTION LOAD OF OTTO-CROSSLEY GAS ENGINE.
(Variations within each cycle averaged.)

The conclusions to be drawn from these curves are simple and patent, and uphold the position taken by the editor years ago in the technical press, viz., that no amount of skill in governor design could make of the Otto-cycle gas engine a well-regulated machine. Here the work of the governor is shown to be of the best. The mean speed of the engine, when measured over so short a period of time as 13.7 seconds, is shown, in Fig. 1, to have risen only 0.08 of 1% above normal under friction load; in Fig. 2 a period of only 6.5 seconds reveals a variation of mean speed from normal of only 0.01 of 1%; in Fig 3 a period of only 3.6 seconds shows a variation from normal of only 0.05 of 1%. Yet the maximum momentary variation of actual speed from normal, at times when the governor was absolutely powerless to prevent it, is, in the first case, 3.4% above and 3.2% below normal, or a total of 6.6%; in the second case it is 3.0% above and 3.1% below, or a total of 6.1%; and in the last case it is 6.0% above and 3.9% below, or a total of 9.9%. In the last case the two extremes occur just exactly 2 seconds of time apart.

The speed variations of the Diesel motor are shown, on the same scale, in Fig. 4. Since the governor of the Diesel motor varies the impulse at each revolution, instead of acting on the hit-or-miss plan of the Otto-Crossley, and since the load was absolutely constant, there was every reason for averaging the records for successive cycles under the same conditions; and the curves are so presented. The two curves represent conditions different only in the load, it being in the first case about 47% of the engine's rating, and in the second case about 9% above rating. The maximum speed variation is not so great as in the Otto-Crossley, being about 4% in the first case and 4.6% in the latter; in each case the mean speed of the cycle (it was not recorded for a

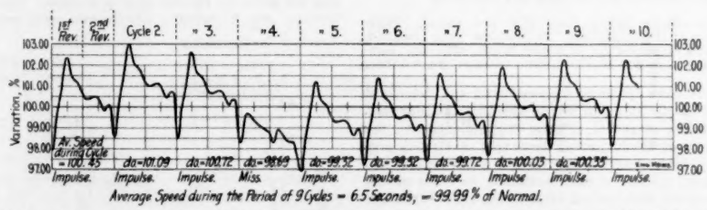

1st Rev.
2nd Rev.
Cycle 2.
Variation, %
Av. Speed during Cycle = 100.45
Average Speed during the Period of 9 Cycles = 6.5 Seconds, = 99.99% of Normal.

FIG. 2.—DIAGRAM SHOWING SPEED VARIATIONS UNDER FULL LOAD OF OTTO-CROSSLEY GAS ENGINE.
(Variations within each cycle averaged.)

*An abstract of the results of the thesis-work of Messrs. Daniel B. Dimick and Walter C. Fuller, of the Class of 1898, and of Messrs. Edmund R. Johnson and Stephen G. Luther, of the Class of 1899; edited by Sidney A. Reeve, Professor of Steam and Hydraulic Engineering; all of the Worcester Polytechnic Institute, Worcester, Mass.

longer period) is so close to normal that the governor must be deemed a very good one. Nevertheless, the similarity of the curves coming from the two engines, so different thermodynamically, is striking.

The message to the designer of gas engines which these curves carry is the obvious limitation in delicacy of regulation applying to all single-cylinder internal-combustion engines, whether operating upon the hit-or-miss or variable-charge

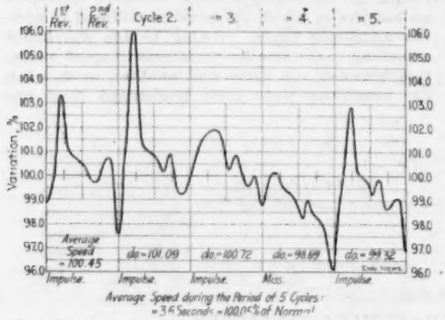


Fig. 3.—Diagram Showing Speed Variations Under Full Load of Otto-Crossley Gas Engine.
(Exact curve as given by chronograph.)

plan. These are both first-class engines, equipped with massive flywheels and excellent governors. The regulation, measured by the same methods as are used upon most steam engines, is excellent. Yet there lies concealed behind this apparent success a weak point, which unfavorable conditions in the way of unusually exacting demands for delicacy of regulation, may at any time exaggerate into an important defect; and the only possible remedy is multiple cylinders.

BOOK REVIEWS.

INTERNATIONAL YEAR BOOK.—Frank Moore Colby, Editor. Dodd, Mead & Co., New York, N. Y. Cloth; 6½ × 10 ins.; pp. 887; illustrated; $3.

This is the second annual issue of this publication which aims to summarize the important events of the current year in a form which will enable them to be referred to by those having occasion to make use of such information. In this issue, which covers the calendar year of 1899, we find a very satisfactory treatment of the South African war and the events which led to the beginning of hostilities; the Hague Conference; the Anglo-Russian agreement respecting China, etc., in the realm of politics. In the domain of science notice may be made of well-written general articles on Archæology, Medicine, Anthropology, Psychology, Geology, Chemistry, Botany and Physics, besides numerous shorter articles on individual subjects coming under one or the other of these heads. The space given to the review of the engineering works of the year aggregates some 35 pages exclusive of illustrations. The department of biography is unusually complete, and fine arts, literature, drama and gazateer matter receive adequate treatment. Altogether the volume just issued presents a large amount of useful information at a very reasonable cost.

TOPOGRAPHIC SURVEYING.—Including Geographic, Exploratory and Military Mapping, with Hints on Camping, Emergency Surgery and Photography. By Herbert M. Wilson, M. Am. Soc. C. E., Geographer U. S. Geological Survey, author of a "Manual of Irrigation Engineering, etc." New York: John Wiley & Sons. Cloth; 9 × 6 ins.; pp. 910; illustrated. $3.50.

The enormous amount of work done by our government surveying organizations, especially in late years, has been accompanied by a rapid development of the science of topographic surveying and the application of every method tending towards system, accuracy and speed of work. In this volume, Mr. Wilson gives the latest practice of the U. S. Geological Survey and such other kindred bodies as have kept in touch with later practice; and as a result, we have a book which will be exceeding useful either in the field and as a work of reference, or as a text book for students in topographic surveying. Bulk is reduced by assuming that the reader has a knowledge of all the more elementary branches; though exceptions are made in some cases. The arrangement of the material used is to be especially commended, as each natural division of the subject is separately and completely treated, with formulas, tables, etc., introduced directly into the text where they are referred to.

Commencing with an explanation of the several kinds of surveys to be made, according to the end to be served, the work proceeds to detail the methods of making these surveys; gives their cost in various parts of the country, and closes Part I. with a glossary of topographic terms as used in the United States. Part II. takes up plane-table work, the stadia and photographic surveying; including in this the instruments, their use and adjustment, methods of calculation and problems involved, and the various ways of measuring linear distance by pacing, estimating by time, by the odometer, tape and chain. Part III. discusses spirit leveling, ordinary and precise; trigonometric and barometric leveling. Part IV. relates to map construction and relief modeling, and with this we have an extended bibliography of works of reference on topography. Part V. takes up in detail terrestrial geodesy; including the methods of base-measurement and its computation, the field work on primary traverse and triangulation, angle measurements, the solution and adjustment of triangles, etc. In Part VI. we have the astronomic methods of obtaining time, azimuth, latitude and longitude, and the use of the instruments and their attachments. Here, too, is given a list of reference works on geodesy. The closing division, Part. VII., describes in a very practical manner the proper camp equipment for a surveying party; the methods of transportation, including in this a description of the famous "diamond hitch" for securing packs; the care of health and the use of photography in surveying. While this a very brief summary of the contents of this volume, it covers the field outlined by its author; gives the very latest practice in surveys of this character, and in manner of presentation and illustration it is in every way commendable.

THE MINERAL INDUSTRY.—Its Statistics, Technology and Trade in the United States and other Countries to the end of 1899. Edited by Richard P. Rothwell, Editor of the "Engineering and Mining Journal," etc. Vol. VIII., supplementing Vols. I. to VII. New York and London: The Scientific Publishing Co. Cloth; 9¼ × 6¼ ins.; pp. 916; illustrated. $5.

This eighth volume of "Mineral Industry" is a worthy successor of the preceding issues, and the introduction states that the figures for 1898 have been revised in the light of later and more minute investigations. The review covers so broad a field that it is impossible to do little more, in the space available, than to touch upon some of its salient features. The purpose of the editors is to present the actual statistics of the mineral industries of the world, as accurately as the means of gathering them will permit; and also to show the latest practice in these industries, and to have this practice written up by experts. Its great value is that it is the only work published in any language that attempts to treat these subjects for the whole world; and for purposes of comparison and gaging of growth, this volume and its predecessors are correspondingly valuable.

THE MUNICIPAL YEAR BOOK of the United Kingdom for 1900.—Edited by Robert Donald, Editor of "The Municipal Journal." London: Edward Lloyd. Cloth; 5 × 8 ins.; pp. 526. 2½ shillings in Great Britain; $1 in America.

This handy volume is packed full of interesting and valuable information relating to English, Scotch and Irish municipalities, both collectively and individually. First of all, there is a compact review of the municipal legislation (parliamentary) of the past year. Then comes a general review of London Municipal Government. This is followed by entries under separate municipalities, including first a general sketch of the city or town, after which leading facts are given regarding baths, cemeteries, libraries, markets, refuse and sewage disposal, slaughter houses, technical education and general statistics. Electric lighting, gas, tramways, water supply and housing of the working classes are treated separately, each of these sections opening with general information, after which the various works in each city or town are described.

THEATRES.—Their Safety from Fire and Panic; Their Comfort and Healthfulness. By William Paul Gerhard, Consulting Engineer for Sanitary Work, etc., etc. Boston, Mass.: Bates & Guild Co. Cloth; 8⅛ × 6 ins.; pp 110.

Mr. Gerhard here discusses the two broad and important questions of safety and comfort as affecting the playgoer. He considers the means of exit for the audience and the actors, in case of fire or panic; measures tending to prevent or to quickly detect a fire; means of saving life, etc. Under the head of comfort and sanitation, he takes up the proper ventilation and heating of theatres, their furniture, drainage and plumbing; water supply, cleansing and periodical inspection. The author has made a careful study of existing conditions in theatres,here and abroad, and points out the weak spots in construction and operation; and then broadly outlines what ought to be done to obviate danger and to increase general comfort.

AMERICAN TELEPHONE PRACTICE.—By Kempster B. Miller, M. E. New York: American Electrician Co. Cloth; 6½ × 9½ ins.; pp. 458; 357 illustrations. $2.00.

This book is made up largely of articles which have appeared in the columns of the "American Electrician." It is unquestionably the best treatise on telephone practice that has yet appeared. The entire field is carefully covered and the matter is plainly written and logically arranged. The illustrations and descriptions of telephone apparatus and circuits are remarkable in that they clearly present a subject that to most minds is the very embodiment of confusion and complication.

As the book is intended first of all for those having charge of the practical management and operation of telephone apparatus little space is given to mathematical treatment of the special electrical and physical problems connected with the science. Such subjects are more satisfactorily treated in monographs and papers before scientific societies.

The scope of the book is well shown by the titles of the various chapters, which are as follows: History and Principles of the Magneto Telephone; History and Principles of the Battery Transmitter; The Telephone Receiver; Carbon Transmitters; Induction Coils; Batteries; Calling Apparatus; The Automatic Shunt; the Hook-Switch and Circuits of a Telephone; Commercial Calling Apparatus; The Telephone Relay or Repeater; Self-Induction and Capacity; Telephone Lines; Simple Switch-Boards for Small Exchanges; Listening and Ringing Apparatus for Switch-Boards; Self-Restoring Switchboard Drops; Complete Switch-Boards for Small Exchanges; Lamp Signal Switch-Boards; The Multiple Switchboard; Transfer Systems; Common Battery Systems; Hotel Systems; Protective Devices; Distributing Boards; Party Lines, Non-Selective; Party Lines, Step-by-Step Selective Signaling; Party Lines, Selective Signaling by Strength and Polarity; Party Lines, Harmonic Systems of Selective Signaling; Wire for Telephone Use; Pole Line Construction; Overhead Cable Construction; Underground Cable Construction; Testing.

A MUNICIPAL PROGRAM.—Report of a Committee of the National Municipal League, adopted by the League, Nov. 17, 1899, together with explanatory and other papers. New York: The Macmillan Co. Cloth; 6 × 8 ins.; pp. 246. $1.

We are pleased to announce the publication of this "Program" in its completed form, accompanied by carefully prepared analyses of its aims and provisions. The "Program" is really an outline of a model municipal charter, applicable to practically all American cities, towns and villages, on properly filling in the outline; in addition, there are proposed constitutional amendments, designed to be sufficiently inclusive to make the adoption of the "Program" possible in any State of the Union. One, several, or perhaps none, of these amendments would be required in the various States, according to the readings of the various State Constitutions. The program as originally submitted was reviewed editorially in this Journal for Dec. 1, 1898. In our issue of Nov. 23, 1899, we published an account of the Columbus convention, at which the "Program," was adopted. That account included brief abstracts or summaries of many of the supplementary papers in the volume before us. As we stated editorially in the issue last named:

> The "Municipal Program," adopted last week by the National Municipal League, is one of the best pieces of constructive work ever done by an organization devoted to the improvement of municipal government.

The "Program" was drawn by a committee of the League, composed as follows: Horace E. Deming, Frank J. Goodnow and Albert Shaw, New York city; Geo. W. Guthrie, Pittsburg; Chas. Richardson, Leo S. Rowe and Clinton Rogers Woodruff (Secretary of the League), Philadelphia. Aside from supplementary papers by members of the Committee, the book contains the following contributions: "Municipal Development in the United States," by John A. Fairlie; "The Power to Incur Indebtedness Under the Proposed Municipal "Program," by Bird S. Coler, and "An Examination of the Proposed Municipal Program," by Delos F. Wilcox.

PUBLICATIONS OF THE JAPANESE EARTHQUAKE INVESTIGATION COMMISSION.—In Foreign languages. Nos. 3 and 4, Tokyo. 1900. Paper; 10 × 7 ins.; pp. 103 and 141; illustrated.

These important publications upon earthquake phenomena are given in English and in French. The contents of Bulletin No. 4 include: Earthquake-proof wooden buildings; effect on a brick building; note on the Mino-Owari earthquake of Oct. 28, 1891; the Tokyo earthquake of June 20, 1894; semi-destructive earthquake of June 20, 1894; after shock of the Hokkaido earthquake of March 22, 1894; elastic constants of rocks and velocity of seismic waves; seismic experiments on the fracturing and overturning of columns. Bulletin No. 3 is devoted to the organization of the commission; its members; study of the resistance to traction in brick joints; apparatus for the theoretical study of earthquakes; scope of the vulcanological survey of Japan.

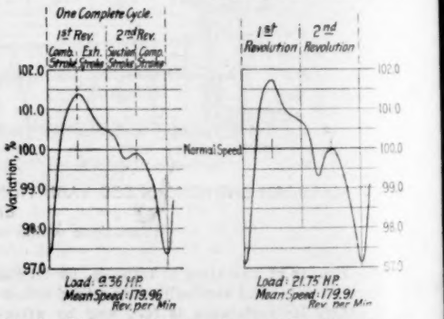


Fig. 4.—Diagram Showing Speed Variations During Single Cycles of 20-HP. Diesel Motor.

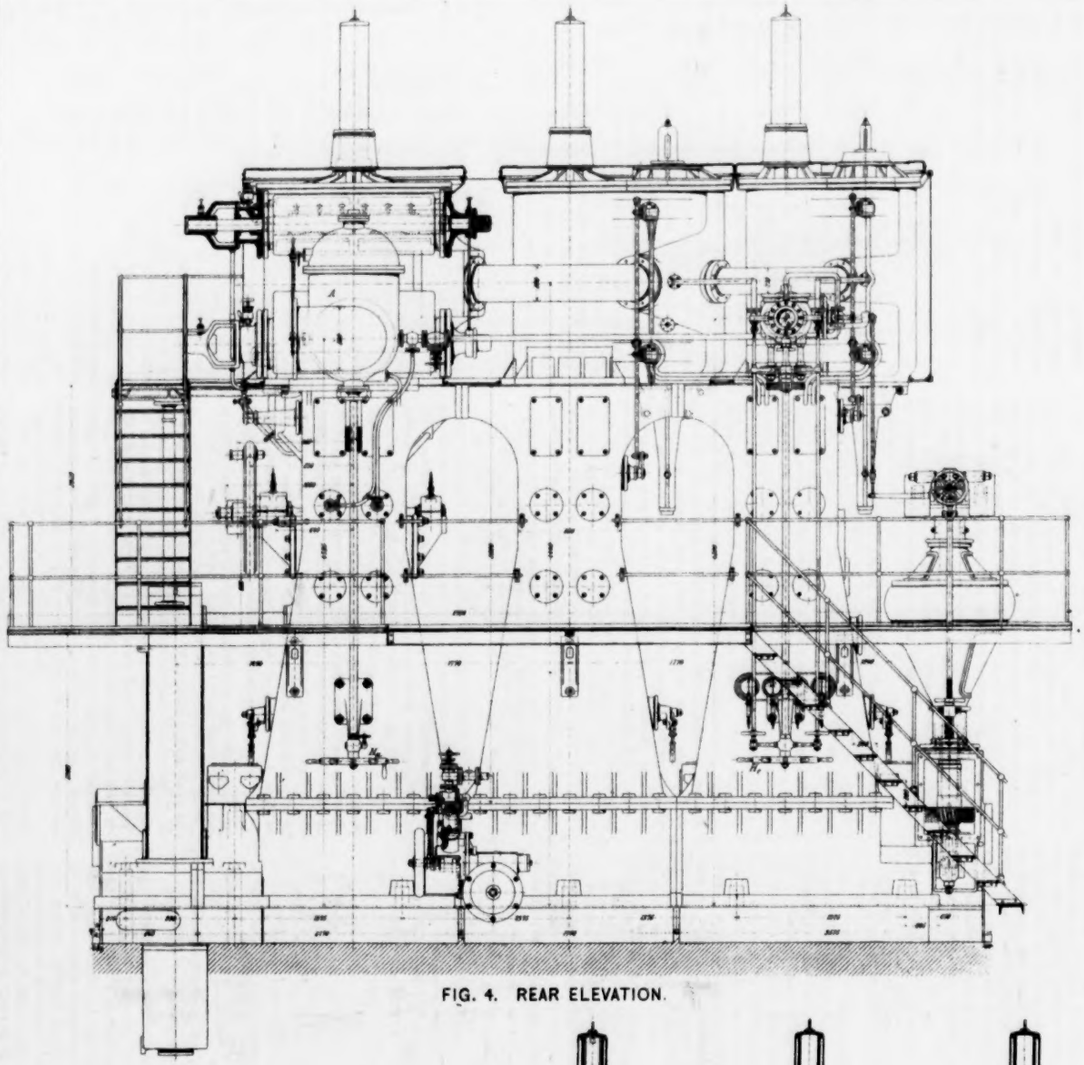


FIG. 4. REAR ELEVATION.

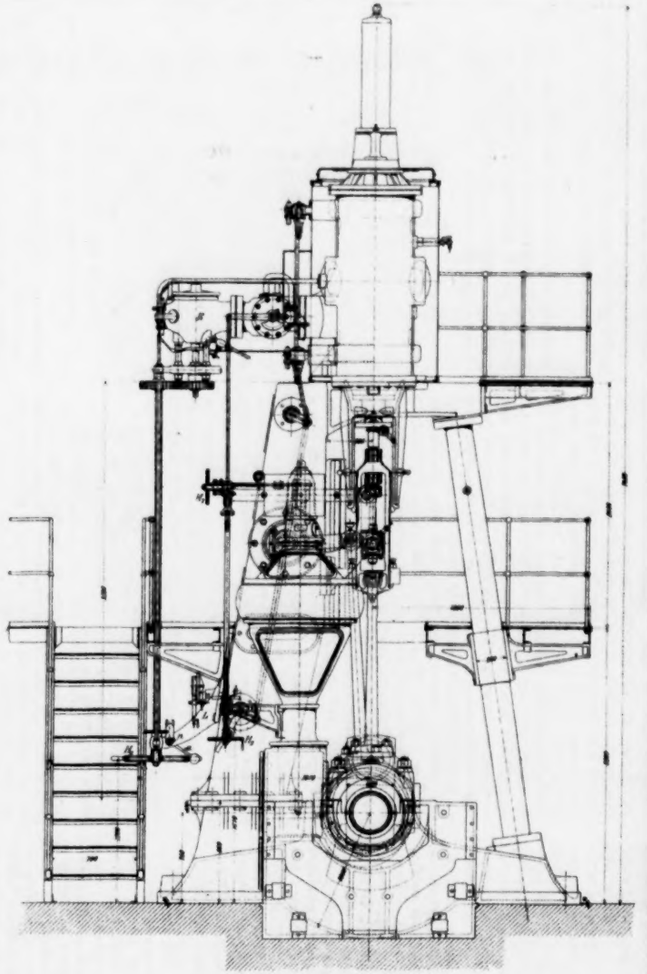
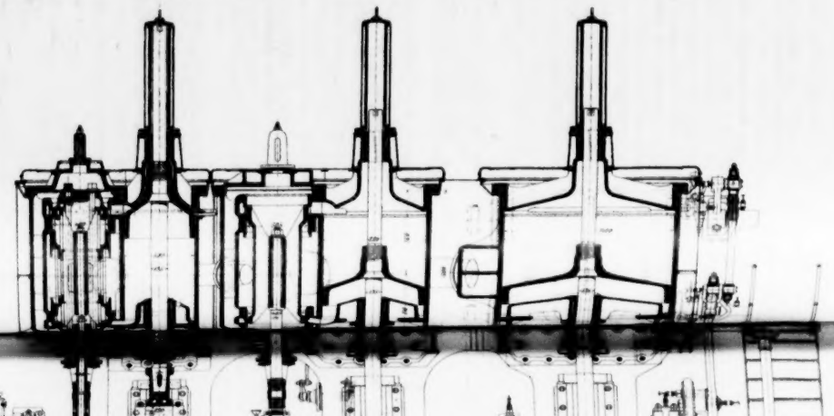
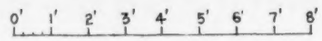


FIG. 5. END ELEVATION.





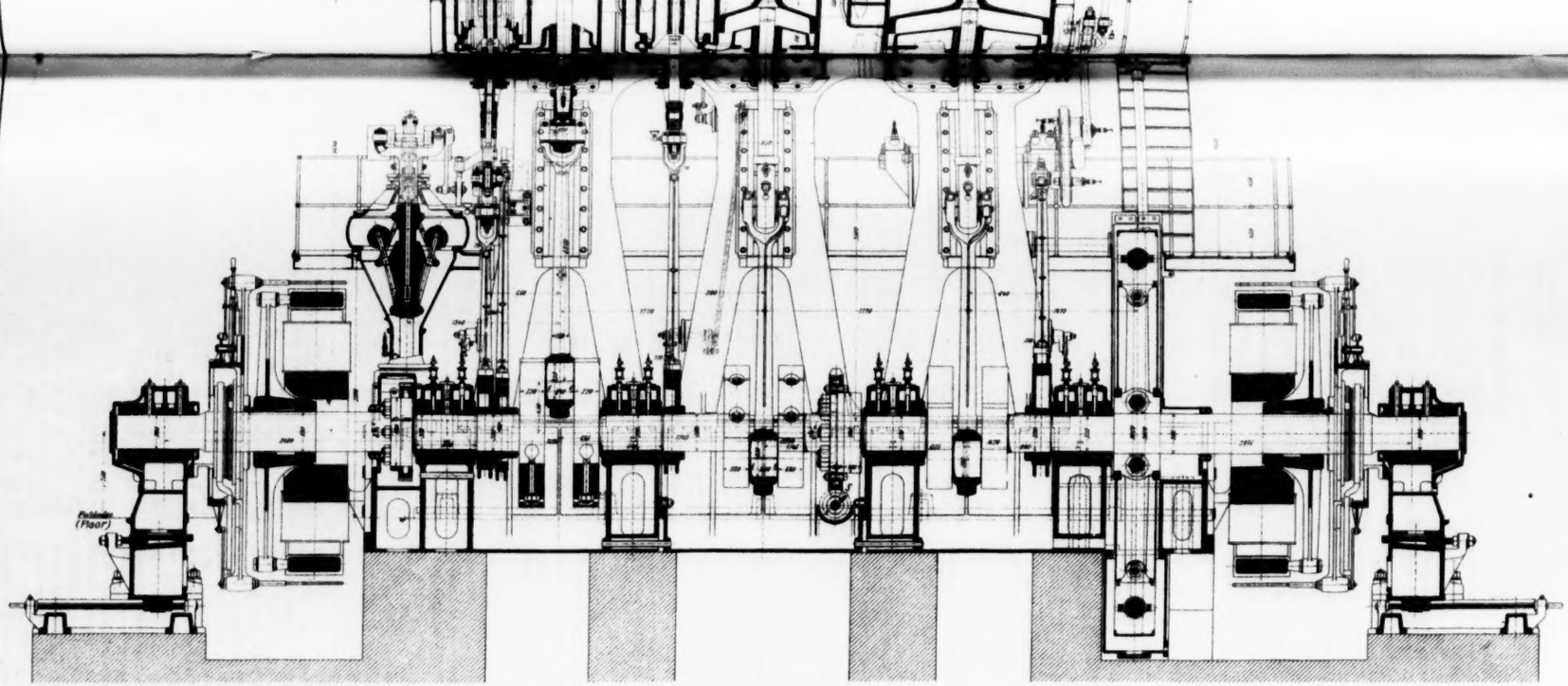


FIG. 6. LONGITUDINAL SECTION.

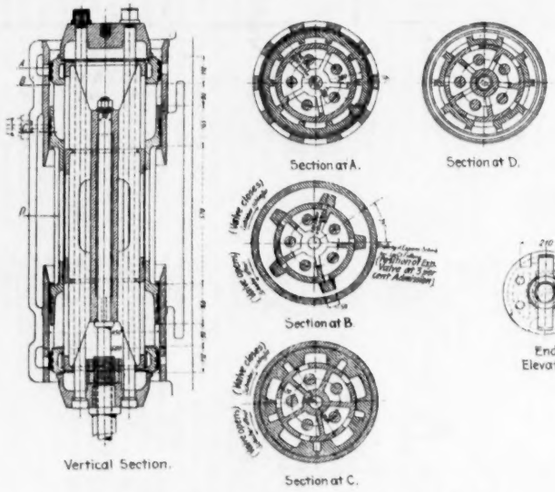


FIG. 1. PISTON VALVE, WITH RIDER AUTOMATIC CUT-OFF FOR HIGH-PRESSURE CYLINDER. AND INTERNAL ADMISSION.

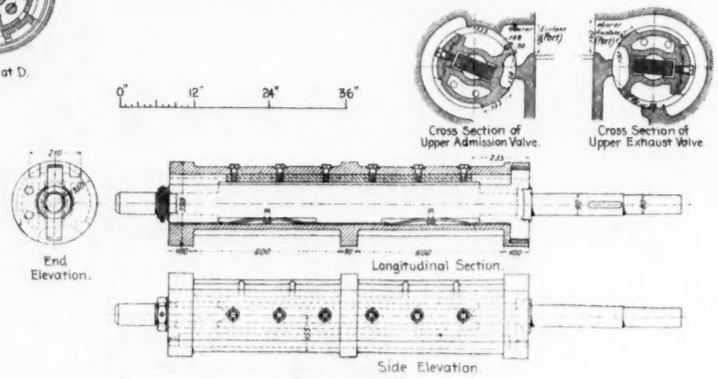


FIG. 2. CORLISS VALVE, FOR LOW-PRESSURE CYLINDER.

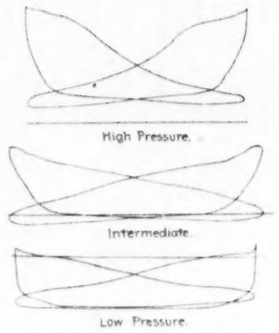


FIG. 3. INDICATOR DIAGRAMS FROM TRIPLE-EXPANSION ENGINE.

HIGH-SPEED, VERTICAL TRIPLE-EXPANSION ENGINE OF 1,500 H.P., FOR THE GENERAL ELECTRIC CO. OF VIENNA, AUSTRIA.

Friedrich Wannieck & Co., Brünn, Austria, Builders.

CHAS. HART, LITH., 26 VESEY ST., N. Y.